A METHOD FOR EVALUATING ACCESS MANAGEMENT ON MAJOR ARTERIAL CROSSROADS IN THE VICINITY OF INTERCHANGES

A Dissertation

by

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ABSTRACT

Access management is a complex field of study that is centered on balancing the needs for access and mobility in order to create a safe and efficient transportation system. While extensive research has been conducted on the topic, the research has typically focused on isolated relationships between a single access management strategy and a single performance measure. Although this information is useful, the isolated relationships make it difficult to ascertain the cumulative effects of a corridor-wide access management project. Consequently, large scale access management decisions are often based on subjective assessments and the engineering judgment of the practitioner. There is a clear need for a consistent, objective, and quantifiable means of evaluating access management impacts and performance on a corridor level.

This dissertation presents a quantitative method for evaluating an access management project based on a variety of factors including operations, safety, impacts to adjacent land uses, and bicycle, pedestrian, and transit facilities. The author developed the Access Management Assessment Tool (AMAT) using a combination of field data, microsimulation analyses, safety investigations, a survey of access management professionals, and findings from previous research efforts.

The final product of this dissertation research is a practice-ready methodology that will allow practitioners to quantitatively and objectively determine a corridor's Access Management Rating (AMR) based upon site characteristics. While the AMAT retains enough flexibility that it can be tailored to a specific agency's needs, it eliminates

the subjective component of the decision making process such that the access management rating for a given corridor is not influenced by the person making the assessment. Use of the AMAT will improve the consistency in which access management decisions are made within the transportation profession. It will also allow for a more efficient use of transportation funds as the corridors most needing access management improvements will be accurately identified.

DEDICATION

To my husband, Matthew, for being an unwavering source of love, support, and reason throughout this entire journey, and for sacrificing so much to make my dreams a reality.

To my beautiful daughter, Audrey, who taught me more about life, love, and joy in her first day on this Earth than I had learned in all of my thirty-two years before.

And to my parents, Roger and Laura, and my sister, Kristina, for teaching me the value of hard work, for encouraging me to pursue my wildest dreams, and for being my biggest fans every step of the way.

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NOMENCLATURE

AASHTO	American Association of State Highway Transportation Officials
AADT	Annual Average Daily Traffic
AIC	Akaike Information Criterion
AMAT	Access Management Assessment Tool
AMR	Access Management Rating
ANOVA	Analysis of Variance
BIC	Bayesian Information Criterion
CMF	Crash Modification Factor
DDI	Diverging Diamond Interchange
df	Degrees of Freedom
FHWA	Federal Highway Administration
FI	Fatal and Injury (Crash)
FM	Full Movement
ft.	Feet
HCM	Highway Capacity Manual
HSM	Highway Safety Manual
ICC	Intraclass Correlation Coefficient
IP	Internet Protocol
IRB	Institutional Review Board
LOS	Level of Service

mph	Miles per Hour
NCHRP	National Cooperative Highway Research Program
ParClo	Partial Cloverleaf Interchange
PDO	Property Damage Only (Crash)
PHF	Peak Hour Factor
RIRO	Right-In, Right-Out
sec.	Seconds
SPUI	Single-Point Urban Interchange
SSAM	Surrogate Safety Analysis Model
TAMU	Texas A&M University
TRB	Transportation Research Board
TTC	Time-to-Collision
TWLTL	Two-Way Left-Turn Lane
vph	Vehicles per Hour
vphpl	Vehicles per Hour per Lane

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CHAPTER I

INTRODUCTION

Access management is a complex field of study that is centered on balancing the needs for access and mobility in order to create a safe and efficient transportation system. The ten principles of access management, as described in the Transportation Research Board (TRB) *Access Management Manual*, are as follows.

1. Provide specialized roadway systems.
2. Promote intersection hierarchy.
3. Locate signals to favor through movements.
4. Preserve the functional area of intersections and interchanges.
5. Limit the number of conflict points.
6. Separate conflict points.
7. Remove turning vehicles from through traffic lanes.
8. Use non-traversable medians on major roadways.
9. Provide a supporting street network.
10. Provide unified access and circulation systems.

Research presented in the TRB *Access Management Manual* suggests that a successfully implemented access management program can reduce delay by up to 60-percent, increase capacity by up to 45-percent, and reduce crashes by up to 50-percent (Williams, Stover, Dixon, & Demosthenes, 2014). Recommended access management strategies touch on nearly every aspect of transportation engineering, from roadway design to signal operations to policy and planning. Because there are countless combinations of strategies that can be implemented, it is impossible to quantify how access management, as a single entity, might affect the transportation system. As a result, previous research efforts have been focused on the impacts of specific strategies, such as the effects of driveway spacing on crash rates, or the effects of median type on roadway speed. While the current body of knowledge is quite comprehensive in this regard, the research results are typically focused on isolated relationships, making it difficult to ascertain the cumulative effects of a corridor-wide access management project. Consequently, large scale access management decisions are often based on subjective assessments and the engineering judgment of the practitioners and decision makers.

This dissertation presents a quantitative method for evaluating an access management project based on a variety of factors, including operations, safety, impacts to adjacent land uses, and bicycle, pedestrian, and transit facilities. The author developed the evaluation methodology using a combination of field data, microsimulation analysis, safety analysis, a survey of access management professionals, and findings from previous research efforts.

Much of the data used in this dissertation was collected as part of a larger study related to access management in the vicinity of interchanges. The author, in conjunction with the project team, collected field data at 16 interchange locations, of which 14 provided usable data for analysis in this dissertation. The field data served as the basis for the operations analyses, including in-depth VISSIM modeling of varying access management strategies along a corridor. In addition, the author conducted a high-level safety investigation and trend analysis using historical crash data from each of the study corridors. Unique to this dissertation effort was a survey of practitioners that provided insight into the state of practice with regards to evaluating access management along a corridor.

The final product of this dissertation research is a practice-ready methodology that will allow practitioners to quantitatively and objectively determine a corridor's Access Management Rating (AMR) based upon site characteristics. The developed methodology is referred to as the Access Management Assessment Tool (AMAT). Although the AMAT retains enough flexibility that it can be tailored to a specific agency's needs, it eliminates the subjective component of the decision making process such that the access management rating for a given corridor is not influenced by the person making the assessment. It should also be noted that while the AMAT can be applied to any corridor, the data set used in its development was limited to major arterial crossroads in close proximity to an interchange.

CHAPTER II

BACKGROUND

The 2014 TRB *Access Management Manual* (Williams, et al., 2014) states,

> "Access management is the planning, regulation, and design of access between a roadway and land development. It encompasses a range of methods that preserve the safety and mobility of the traveling public by reducing conflicts on the roadway system and at its interface with other modes of travel."

The primary motivation for implementing access management techniques is to balance the concepts of access and mobility, thereby improving safety for all users, including drivers, bicyclists, and pedestrians. The concepts of access management cover a broad spectrum of application methods, from high-level land use planning to signal timing optimization, and a great deal of research has been completed on the impacts of access management. However, the majority of research that has been conducted has focused on isolated relationships between a specific access management strategy (e.g. driveway spacing or median design) and a specific performance measure (e.g. crash rates or corridor travel time). Very few studies have investigated how a certain access management strategy affects multiple performance measures, and even fewer have taken a comprehensive look at the cumulative impacts of implementing multiple access management strategies.

Access Management Principles

Access management includes a wide array of strategies involving transportation planning, design, and operations. Each strategy stems from one of the ten principles of access management, as outlined in the TRB *Access Management Manual* (Williams, et al., 2014). These principles are briefly discussed below.

Provide Specialized Roadway Systems

Effective short-term and long-term policies and planning, including land use plans, site development requirements, and access permitting policies can ensure that roadways continue to function in a manner that aligns with their intended design.

Promote Intersection Hierarchy

Intersecting roadways should not differ by more than one functional classification. For example, a minor arterial roadway can connect to a major arterial or major connector street, but should not connect to a freeway.

Locate Signals to Favor Through Movements

Corridor operations can be significantly improved by introducing signal progression, which is best achieved when signalized intersections are uniformly spaced according to roadway speeds.

Preserve the Functional Area of Intersections and Interchanges

The separation of the functional area of driveways, intersections, and interchanges improves both safety and operations. When overlapping functional areas exist, drivers may not have adequate time or distance to safely complete their desired maneuvers before their attention is required at the next functional area. Providing adequate spacing between driveways and intersections is a key strategy of access management.

Limit the Number of Conflict Points

A conflict point exists anywhere that two travel paths cross. As the number of conflict points increases, the likelihood of crashes increases. These crashes and near-crashes also negatively impact roadway operations. Reducing the number of conflicts on a corridor is most commonly achieved by limiting the number of access points and by restricting turning movements through the use of raised medians.

Separate Conflict Points

Similar to the functional area of intersections and driveways, separating conflict points by increasing driveway and intersection spacing as well as restricting turning movements can improve both safety and operations.

Remove Turning Vehicles from Through Traffic Lanes

The speed differential between through traffic and turning traffic is considered one of the most significant factors impacting the safety and operations of a roadway. Auxiliary lanes should be provided for turning vehicles when appropriate.

Use Non-traversable Medians on Major Roadways

Non-traversable, or raised, medians nearly eliminate the presence of head-on vehicle crashes. Additionally, these medians can also restrict turning movements at driveways and intersections which reduces the number of conflict points and separates functional areas.

Provide a Supporting Street Network

A well-planned supporting street network can greatly reduce the number of necessary access points along a corridor. Collector roadways that run parallel and perpendicular to a major corridor can provide efficient access for individual developments instead of each parcel requiring access to the major roadway.

Provide Unified Access and Circulation Systems

The final access management principle promotes efficient site plan development that includes shared access between parcels and circulating roadways within a larger development. This allows for fewer access points on the major roadway and also allows vehicles to travel between developments without using the major roadway.

Impacts of Access Management

The impacts of access management typically fall into at least one of three categories: safety, operations, or economics. The vast majority of access management research relates to its impact on roadway and driveway safety, roadway operations, and the vitality of adjacent land uses. The following subsections present the current body of knowledge on the impacts of various access management strategies. A table summarizing the relevant findings is also included in Appendix A.

Safety Impacts of Access Management

Previous research has shown that the number of crashes at driveways is disproportionately high compared to crash rates at other types of intersections; thus, driveway safety is of particular importance and is considered in a wide array of access management research efforts (American Association of State Highway and Transportation Officials (AASHTO), 2011).

One of the most commonly studied access management factors, as related to safety performance, is the density or spacing of driveways. Research findings presented in National Cooperative Highway Research Program (NCHRP) Report 420 (Gluck, Levinson, Stover, 1999) suggest that the addition of one access point per mile will result in a four-percent increase in corridor crash rates. These findings are consistent with a similar research effort by Papayannoulis, et al. (1999) who estimated a 40-percent increase in crash rates at locations where driveway density increased from 10 to 20 access points per mile. A 2012 research effort in Oregon suggested that access density and land use are both significant variables for predicting urban corridor crashes, while in rural areas land use, access density, and clustering of access points are significant predictors of crashes (Dixon, Avelar, Brown, Mecham, & van Schalkwyk, 2012). Table 1 presents a comparison of driveway density impacts on crash rates, as found in several different studies. The table is adapted from Exhibit 2-2 in the 2014 TRB *Access*

Management Manual, and was originally developed from data presented in NCHRP Report 420.

Table 1. Comparison of Research Findings Relating Driveway Density to Crash Rate Indices (Adapted from Exhibit 2-2 in the 2014 TRB Access Management Manual by Williams, et. al)

Access Points Per Mile	**Urban and Suburban Roads**			**All Roads**		**Average**
	Safety Analysis	Minnesota Study	Indiana Study	Literature Synthesis	Square Root Rule	
10	1.0	1.0	1.0	1.0	1.0	1.0
20	1.4	1.4	1.2	1.3	1.4	1.3
30	1.8	1.7	1.5	1.7	1.7	1.7
40	2.1	2.1	1.8	2.1	2.0	2.0
50	2.3	2.5	2.1	2.8	2.2	2.4
60	2.5	2.9	2.5	4.1	2.7	2.9
70	2.9	3.1	3.0	-	2.7	2.9

Another often studied access management strategy is the selection of median type and associated turning movement restrictions. Several previous research efforts have indicated that continuous two-way left-turn lanes (TWLTLs) have a better safety performance compared to undivided roadways when driveway density is high and traffic volumes are low; however, roadways with TWLTLs still have a lower safety performance than roadways with raised medians (Squires & Parsonson, 1989; Margiotta & Chatterjee, 1995). Additional studies suggest the same trend in median safety performace, although their specific findings differ. Research in NCHRP Report 420 suggests that replacing a TWLTL with a raised median can reduce crash rates by 30 to 50-percent, and providing a TWLTL on an otherwise undivided roadway reduces the crash rate by 10 to 20-percent (Gluck, Levinson, Stover, 1999). Parsonson, Waters, and Fincher found similar safety performance values in their 1993 study. However, another study completed in 2000 found that providing a TWLTL on an otherwise undivided roadway reduces crashes by 35-percent, while replacing a TWLTL with a raised median reduces crashes by 15 to 57-percent (S&K Transportation Consultants, 2000). The same study suggested that providing a raised median on an otherwise undivided roadway reduces crashes by up to 55-percent.

Operational Impacts of Access Management

Several decades of research have highlighted the operational benefits of various access management techniques, as summarized by Koepke and Levinson (1992) who wrote, “Inadequate and ineffective access management underlies the deterioration of many streets and highways.”

One of the most common measures of the operational impacts of access management is travel speed. Turning vehicles, particularly right-turning vehicles, must reduce their speed significantly prior to entering a driveway. This slowing maneuver impacts the speeds of other vehicles both behind and next to vehicle. Methods outlined in the 2010 TRB Highway Capacity Manual (HCM) can be used to show that additional driveways result in decreased roadway speeds, and a decrease in free-flow speed relates to a reduction in roadway capacity. More specifically, free flow speeds decrease by an average of 2.5 mph for every additional 10 access points per mile. Research conducted by McShane, et al. in 1996 used microsimulation to estimate the effects of driveway density on travel speed. Their findings suggested that increasing driveway density from zero to eight driveways per mile (on one side of the road) reduces travel speed in the primary direction by 5 mph. Increasing the driveway density to 16 driveways per mile results in primary direction speed reduction of 7 mph and opposing direction speed reduction of 2 to 3 mph. The density or spacing of signalized intersections has a more pronounced impact on corridor operations. Research presented in NCHRP Report 420 (Gluck, Levinson and Stover, 1999) investigated the impacts of signalized intersection spacing on corridor travel time, as summarized in Table 2.

Table 2. Relationship Between Signalized Intersection Spacing and Travel Time (Source: Gluck, Levinson, and Stover, 1999, Table 3)

Number of Signals Per Mile	Percent Increase in Travel Times (Two Signals Per Mile as Base)
3	9
4	16
5	23
6	29
7	34
8	39

Median configuration also has a proven impact on corridor operations. In 1997, Bonneson and McCoy studied the operational effects of mid-block left-turn lanes. They concluded that roadways with raised-curb medians and TWLTLs medians generated similar levels of delay, and both scenarios yielded delays significantly lower than expected for undivided roadways. Additional research has shown that providing a TWLTL or a raised median on an otherwise undivided roadway reduces delay by 30-percent and increases capacity by 30-percent (S&K Transportation Consultants, 2000).

Land Use Impacts of Access Management

There is a direct and cyclical relationship between roadway function, access management, and land use. Existing land uses require specific access configurations and generate certain levels of traffic, both of which influence the functionality of the roadway. On the other hand, the functionality, accessibility, and design of a newly constructed roadway will attract specific types of land uses. Although a link is clearly present, very few research efforts have successfully quantified the impacts of access management on land use (and vice versa).

The most substantial body of research relating to access management and land use is focused on the economic impacts of access management strategies on adjacent land use, and specifically on adjacent businesses. Although this dissertation does not directly address the economic impacts of access management, it does take into account potential impacts to adjacent land uses, and thus the topic is included in this literature review.

As part of NCHRP Report 395, public opinion surveys indicated that quality of service and quality of products were ranked much higher than property access in regards to factors affecting a customer's choice to visit a business (Bonneson and McCoy, 1997). This suggests that for certain business types, any negative economic impacts related to access restriction, such as reduced patronage or decreased profits, could be counteracted by service and product quality improvements. Eisele and Frawley (1999) utilized an almost identical survey when studying Texas locations and found strikingly similar results. A more comprehensive study in Washington State combined public opinion surveys with existing land use data to develop customer behavior models, and the findings indicated a direct correlation between access management techniques and business patronage (Vu, Shankar, and Chayanan, 2002). In 2012, Eisele, et al., conducted another study investigating the conversion of two-way frontage roads to one-way frontage roads, including public opinion surveys as well as an analysis of assessed land values. Based on long-term economic trends, the researchers concluded that the operational conversion did not negatively affect businesses over a prolonged period of time. Lastly, a 2015 study in Texas used taxable sales records as a measure of economic impact and found that, relative to control locations, sales increased or remained constant after access management projects were implemented (Benz, Norboge, Voigt, & Gage, 2015).

A much smaller amount of research is available on topics not related to economic impacts. Research completed by Gattis, Balakumar, and Dunacan (2005) suggested a possible link between median type and land use, but the relationship was not quantified. In 2015, Brown and Dixon investigated the possibility of using access travel time as a measure of how driveway restrictions impact corner lot developments. Their findings suggest that when a development has access to the minor road, providing additional access to the major road does not always improve the ability for customers to access the site, and in some cases additional access may actually increase the minimum time required to access the development.

With regard to land use and safety, Bindra, Ivan, and Jonsson (2009) suggested that using actual land use data (retail versus non-retail, number of employees, etc.) in crash prediction models provided much more accurate predictions of segment-intersection crashes than typical driveway data. A 2012 study conducted in Oregon (Dixon, et al.) found a similar link between land use variables and crash patterns, identifying commercial and industrial land uses as being particularly significant. These findings suggest that driveway traffic volume characteristics, which are directly influenced by land use, are better predictors of segment-intersection crashes than the location or design of the driveway.

Although a significant amount of research has been completed relating access management and land use, particularly in the area of economic impacts, none have successfully quantified a direct relationship between land use and access management strategies. However, it is apparent that even without a quantifiable relationship available, a significant link does exist, and impacts to adjacent land uses should be included in a methodology that aims to thoroughly evaluate access management along a corridor.

Summary of Literature on Access Management Impacts

Access management related research has primarily focused on safety, operations, and land use impacts. The existing body of knowledge is extensive, but much of the research typically relates a single access management strategy to one or two performance measures, particularly on the topics of safety and operations. On the other hand, economic-based research tends to relate overall access management along a corridor (which involves multiple strategies) to a single type of performance measure. This literature review shows that while a significant amount of knowledge exists, the current body of research cannot be used to easily estimate how a given access management strategy (or a combination of several strategies) will simultaneously impact the transportation system and surrounding land uses. This gap highlights the need for a quantitative method, based on previous research as well as new data, to comprehensively evaluate the performance of access management with respect to safety, operations, and land use impacts.

Safety Analysis Methods

Numerous analysis methods exist for evaluating the safety performance of a roadway segment, intersection, or corridor. The methods range from qualitative approaches like the Roadway Safety Audit (based on subjective ratings) to highly analytical quantitative methods involving advanced statistical analyses (crash prediction models). Metrics for assessing safety performance typically include crash severity, crash frequency (number of crashes), or crash rate (crashes per 100 million vehicle miles traveled). The Highway Safety Manual (HSM) and the Surrogate Safety Analysis Model (SSAM), summarized below, are the products of two nationally-funded efforts aimed at providing a comprehensive, quantitative method for evaluating safety performance.

Highway Safety Manual

The HSM, published by AASHTO in 2010, provides the first systematic approach to quantitatively and analytically assessing the safety performance of roadways and intersections. The backbone of the HSM is the predictive method which utilizes the results of sound statistical analyses (safety performance functions and crash modification factors) to estimate the expected frequency and severity of crashes based on roadway characteristics and traffic volume. The HSM provides methods for evaluating rural two-lane and multi-lane roadways as well as urban and suburban arterials. Depending on the facility type, the HSM predictive method can take into account specific access management factors such as driveway density, median configuration, and signalized intersection density, typically through the application of crash modification factors (CMFs). However, the data and research methods to develop the crash modification factors varies widely and may not always be applicable to a given location.

Surrogate Safety Analysis Model

The SSAM was developed by the Federal Highway Administration (FHWA) in 2008 (Pu & Joshi, 2008). SSAM utilizes trajectory output from microsimulation analyses, such as VISSIM, to estimate the number of vehicle conflicts within a network. The analysis method is similar to a traditional conflict evaluation conducted in the field in which details about near-collisions are recorded and later correlated to crash risk. SSAM identifies vehicle conflicts or near-collisions based on a number of factors including time-to-collision (TTC), differences in vehicle speed, differences in vehicle deceleration, and relative vehicle trajectories. Each identified conflict is classified as crossing, lane change, or rear end according to the relative trajectory angle between two vehicles. The research team that developed SSAM validated the model using a combination of field data from 83 sites, sensitivity analyses, and comparisons with traditional theoretical crash prediction methods. In addition to validating the SSAM methodology, the program documentation also provides a developed equation (see Equation 1) which correlates the number of conflicts identified in SSAM with expected crash frequencies.

Equation 1. SSAM Relationship Between Total Crashes and Total Conflicts

$$\frac{Crashes}{Year} = 0.119 \times \left(\frac{Conflicts}{Hour}\right)^{1.419}$$

Summary of Safety Analysis Methods

Both safety analysis tools described above allow for the quantitative evaluation of safety performance based on varying roadway characteristics. For this dissertation, using SSAM is preferred over the HSM for two primary reasons. First, the ability to run the SSAM analysis using VISSIM files ensures that the safety and operational analyses are based on exactly the same roadway characteristics. Second, the observed safety impacts of access management strategies will be based solely on the results of the conflict analysis instead of being based on the findings of previous research efforts (such as those used to develop CMFs in the HSM).

Operations and Land Use Analysis Methods

The methods outlined in the HCM serve as the national guidelines for analyzing the operational performance of a roadway segment or intersection. A level of service (LOS) rating on a scale of A through F is the final result of the analysis methods in the HCM. The HCM includes procedures for calculating automobile, pedestrian, bicycle, and transit LOS on appropriate facility types. For automobiles, the metrics used to determine a LOS designation vary by facility type and may include vehicle delay, travel speed, vehicle density, or the percentage of time spent following.

There are no standard methods for evaluating impacts to land uses. As shown in the literature, the most common approach involves economic analyses based on property values, tax records, or survey data collected before and after a roadway improvement project. Metrics for the impacts to land use typically include either documented or perceived (by the business owner) changes in property value, profit, or patronage. Beyond economic analyses, one previous research effort identified access travel time (the minimum time required to enter and exit a development) as a possible metric of land use impacts.

CHAPTER III

OVERVIEW OF RESEARCH APPROACH

This chapter provides a brief overview of the research conducted as part of this dissertation.

The research described in this dissertation is closely tied to a larger research project sponsored by the NCHRP project titled "Access Management in the Vicinity of Interchanges", NCHRP Project 07-23. The goal of this NCHRP project is to develop a guidance document on recommended access management strategies for crossroads within close proximity of a grade-separated interchange. A significant portion of the data used in this dissertation was obtained as part of the NCHRP research effort. As such, the NCHRP project team made many of the decisions regarding study site selection, data collection, and data reduction.

Figure 1 depicts a general overview of the research tasks as they relate to the development of the AMAT. The research approach is further described in the following sections.

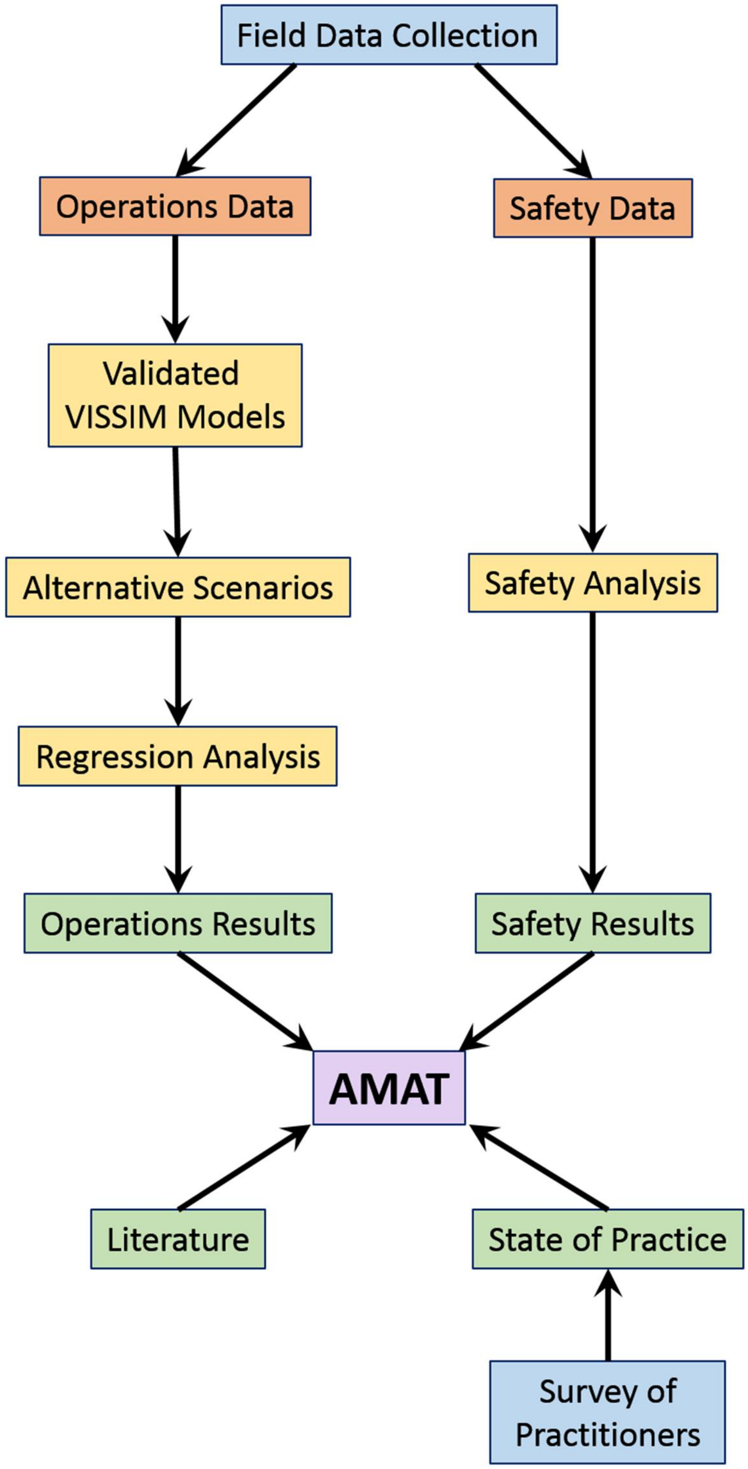


Figure 1. Overview of AMAT Development

State of Practice

The author developed a survey to gather insight into how transportation and access management professionals subjectively evaluate corridor access management. The survey provided an aerial photo, street-view photo, and general information about a given corridor and asked respondents to rate the corridor on a scale of one to five (five being excellent). The survey also asked respondents to identify the key factors that influenced their decision. A total of 59 professionals completed the survey. A description of the survey and discussion of the key findings can be found in Chapter IV, while a comparison to the AMAT results and subsequent adjustments can be found in Chapter VII. Appendix B includes the full text of the survey as well as a summary report of the results.

Data Collection and Reduction

The data collection effort provided geometric, operations, safety, and land use data for 16 interchange locations across five states. This data is summarized for each site in Appendix C. The project team conducted site visits to collect travel time data and record video observations of corridor operations during peak and off peak traffic conditions. Members of the research team, as well as subcontractors, reduced the raw data (video and travel time) to obtain roadway traffic volumes, driveway traffic volumes, intersection queue lengths, corridor travel time, vehicle speeds, and signal timing. Video data in conjunction with aerial imagery (Google Earth) provided data related to roadway and driveway geometric design as well as adjacent land uses. Finally, the project team acquired three years of historical crash data from local and state agencies for each of the study corridors. More detailed information regarding the data collection effort can be found in Chapter V.

Data Analysis

The data analysis effort utilized the microsimulation program VISSIM (v. 7.0) to analyze the operational impacts of access management, while the safety impacts analyses relied on descriptive statistics and trend analysis.

Of the original 16 data collection sites, the author analyzed 10 sites in VISSIM after reserving four sites for use in the survey effort and excluding the two alternative interchange types (roundabout terminals and the diverging diamond interchange) due to their unique design and operations. The author developed base models of each site during peak and off peak conditions and validated each model with respect to corridor speed. Once the base models were validated, alternative scenarios could be developed to investigate the impacts of various access management techniques. Each alternative scenario varied in terms of roadway and driveway traffic volume, driveway placement, turning movement restrictions, and median type, among others. The author then used regression analyses to identify which access management factors had significant impacts on operations, as measured by corridor vehicle speeds.

The SSAM software package is capable of analyzing safety performance using vehicle trajectory data exported directly from VISSIM. Because of this, SSAM was potentially the ideal tool for evaluating the safety of each corridor under identical characteristics as those used for operations based analyses. Unfortunately, attempts to validate the SSAM crash estimates against historical crash data failed, and the author determined that SSAM was not suitable for analyzing the safety impacts of access management on the given corridors. As a result, the author had to rely solely on the historical crash data available at each site, thus dramatically reducing the amount of available safety data from several hundred data points to 20 (two sides of 10 interchange locations).

More detailed descriptions of the data analyses and results are presented in Chapter VI. Appendix D includes information on the validation of the operational analysis models.

AMAT Development

The data analysis effort helped the author identify the access management related factors that had significant impacts on safety and operations. Working with these factors as a starting point, the author finalized a set of data variables to be included in the AMAT. The author then developed individual rating scales for each of the selected data variables according to their relative impacts on safety, operational, and land use accessibility (for purposes of this dissertation, the term "accessibility" simply refers to the general ability to access a development; it is not specifically related to disabled or handicap access considerations). These rating scales were based on a combination of the results of the regression analysis, previous research findings, and engineering judgment.

The AMAT combines the individual rating scales to determine a categorical assessment score for safety, operations, and land use accessibility. The final output of the AMAT is an AMR, which is a single numerical rating for the entire corridor.

The development of the AMAT was centered on data-driven analyses, published research, and sound methods that provided objective information on the relative performance of access management strategies along a corridor. As such, the results of the AMAT will differ from the subjective assessments gathered in the survey of practitioners. However, the author felt it important to understand the nature and extent of the differences between the AMAT and survey, even if those differences did not automatically justify adjustments to the AMAT. A comparison of the AMAT ratings and survey results for the six study corridors is presented in Chapter VIII.

Example Problems

The final phase of the project, presented in Chapter VII, involved the development of two example problems which clearly describe how the AMAT can be applied to a corridor. In addition, Chapter VIII also includes recommendations for default values and guidelines for adjusting the AMAT.

CHAPTER IV

STATE OF PRACTICE

A critical step in developing a new methodology for evaluating access management is to first understand the current state of practice. To do so, the author surveyed access management practitioners and general transportation engineers to gather insight into the decision making processes currently utilized with regards to evaluating access management performance along a corridor. This survey was not part of the NCHRP project and thus the author developed the survey without direction from the project team. This chapter summarizes the survey development, implementation, and results.

Survey Development

The purpose of the survey was to better understand how transportation professionals currently evaluate access management along a corridor using their own subjective assessments. The most difficult aspect of the survey development was balancing the need to keep the survey simple and streamlined while still providing adequate information about each location. There are countless factors related to access management to some degree, and including information about each one would be overwhelming to a survey participant. However, providing information relating to only a handful of factors may inadvertently convey that the selected factors are more important than excluded ones. The author chose to explicitly include only the information that could not be easily gleaned from aerial and street view photography, such as traffic volume and posted speed limit, or where the classification of a characteristic might not be clear, such as a continuous raised median versus a raised median with strategic openings. While the precise land use cannot be determined from aerial photography, characteristics such as building size and parking lot layout can provide sufficient clues to determine the general category of land use (e.g. commercial versus residential).

The survey was comprised of two sections, one with a series of demographic-related questions and the second with questions related to access management on specific corridors. The demographics questions asked for the participant's sector of employment, their experience with access management, and their area of expertise within the transportation industry, among others. The second portion of the survey provided examples of six different corridors and asked the following two questions about each corridor:

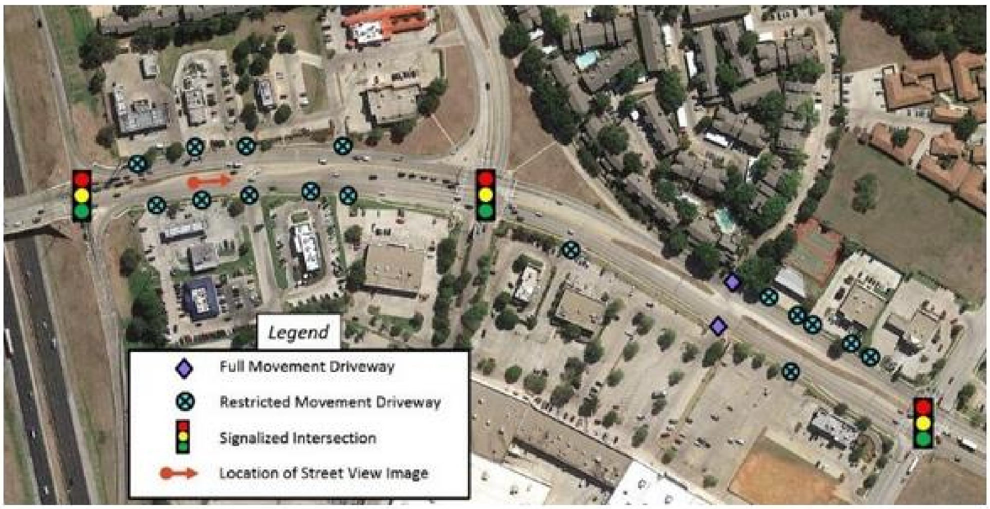
- How would you rate the level of access management of the given corridor on a scale of one to five (with five being excellent)?
- What factors most influenced your rating selection?

An example of the corridor-related information that accompanied each set of questions is shown on Figure 2, while the complete survey is included in Appendix B.

. Please review the following information and pictures describing Corridor 1, then answer the questions at the bottom of this page.

Corridor Information:
6-Lane Arterial
Median: Raised with Strategic Openings
Posted Speed Limit: 40 mph
Corridor Length: 0.38 miles
AADT: 17,000 vpd

. **Aerial View of Corridor 1 (click here for a larger image)**



. **Street View of Corridor 1 (click here for larger image)**

Figure 2. Example of Corridor Information Included in Survey

The survey included six corridors from four different interchange locations, as summarized in Table 3. In order to maintain independent data sets, the author excluded the four interchange locations from the safety and operational analyses discussed in Chapter VI. The author programmed the survey to randomize the order in which participants viewed and rated the six corridors.

Table 3. Summary of Interchange Locations Used in Survey

Corridor Number	Interchange Site Code	Side of Interchange
1	TX 1	South
2	VA 3	West
3	TX 2	North
4	VA 2	West
5	AZ 6	East
6	AZ 6	West

Survey Implementation

The Texas A&M University (TAMU) Institutional Review Board (IRB) approved the survey, proposed implementation procedures, and recruiting material.

Data Collection Procedures

Once IRB provided approval, the author used the online survey tool, Qualtrics, to create the user interface for the survey. Prior to recruiting participants for the survey, a group of ten selected participants (close colleagues and classmates) beta-tested the survey to ensure that the user interface operated correctly and that the appropriate data was accurately collected.

After thoroughly testing the survey, the author recruited participants via the TRB Access Management Committee mailing list. The exact text used in the recruitment email is included in Appendix B. The mailing list included 160 recipients, and each recipient was encouraged to forward the survey to others who may have been interested in participating. Depending on the extent of the secondary distribution, up to 500 potential participants received an invitation to take the survey. A total of 78 participants responded to the survey during the two week period in which the survey was available.

Data Reduction Procedures

Due to the simplicity of the survey and the customizable output provided by Qualtrics, the collected survey data did not require a concerted reduction effort.

Data Errors and Limitations

The author used Internet Protocol (IP) addresses to identify and remove duplicate survey responses prior to saving and analyzing the data. Additionally, the author removed incomplete survey responses as well as any responses with a total active completion time less than three minutes. After removing said data, 59 of the original 78 survey responses provided usable data points.

Survey Results

The survey was completed by 59 transportation professionals from the United States, Canada, Australia, and Poland. The following sections summarize the demographics of the participants, the corridor rating results, and key findings from the survey effort.

Participant Demographics

Approximately half of the survey participants indicated that they were a licensed professional engineer or their country's equivalent. Their years of experience in the transportation industry ranged from one year to 50 years, with an average of 20 years. Table 4 shows the breakdown of areas of expertise for the survey participants (participants were allowed to select more than one answer). The most common responses in the "other" category were land development planning, permitting, and access management.

Table 4. Survey Participants by Area of Practice

Answer		Responses
General Engineering		12
Highway Design		11
Planning & Policy		30
Traffic Operations		28
Transportation Safety		23
Other (please specify):		13
Total		117

The majority of survey participants were employed by state or federal government agencies or private consulting firms, as shown in Table 5.

Table 5. Survey Participants by Place of Employment

Answer		Response
City or County Government		3
State or Federal Government		31
Metropolitan Planning Organization		2
University or College		3
Private Consultant		19
Advocacy Group		0
Research		1
Total		59

Figure 3 summarizes the level of familiarity and experience the participants had in the area of access management. Approximately 60-percent of participants worked on access management projects regularly or considered themselves an expert in access management.

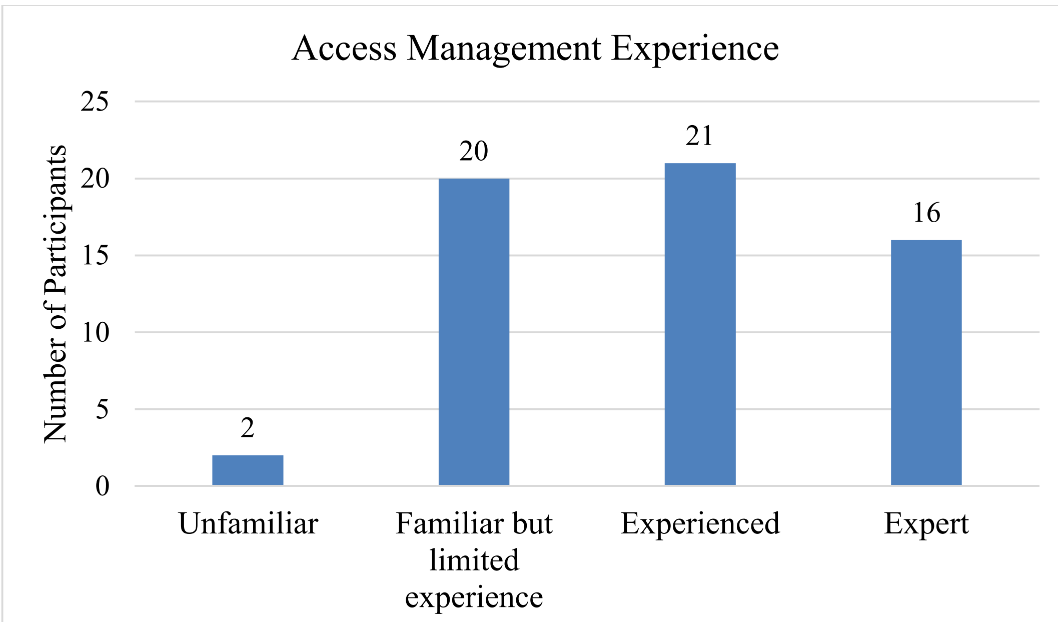


Figure 3. Survey Participants by Access Management Experience

Corridor Rating Results

As anticipated, the corridor ratings varied significantly for each of the six corridors. Three of the corridors were given every possible rating (one through five) by at least one participant. To better visualize how the corridors were being rated, the author grouped the responses by the participant's experience with access management. The following graphs (Figure 4 through Figure 9) show the corridor rating distributions for each corridor. Photos of each corridor and the corresponding rating results are included in Appendix B. The group labeled "Low AM Experience" includes those that were either unfamiliar with access management or had only a working knowledge of access management. Those who worked on access management projects regularly or were considered experts in the field are included in the "High AM Experience" group.

Corridor 1 was a six-lane urban arterial corridor with a raised median with strategic openings. The posted speed limit was 35 mph, the AADT was 17,000 vpd, and the corridor length was 0.38 miles. There were 16 restricted movement driveways, two full movement driveways, and three signalized intersections within the corridor extents. The survey rating results for Corridor 1 are shown on Figure 4.

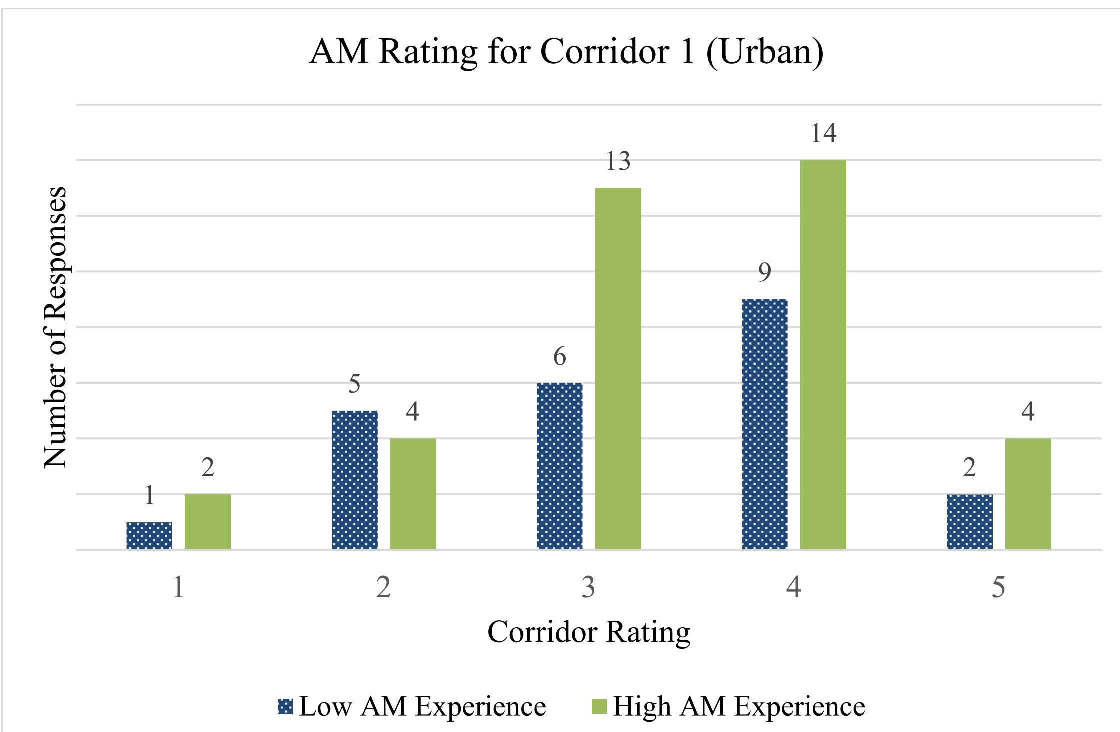


Figure 4. Survey Rating Results for Corridor 1

Corridor 2 was a rural two-lane highway with no median. The posted speed limit was 35 mph, the AADT was 12,000 vpd, and the corridor length was 0.51 miles. There were 21 full movement driveways, two stop-controlled intersections, and one signalized intersection within the corridor extents. The survey rating results for Corridor 2 are shown on Figure 5.

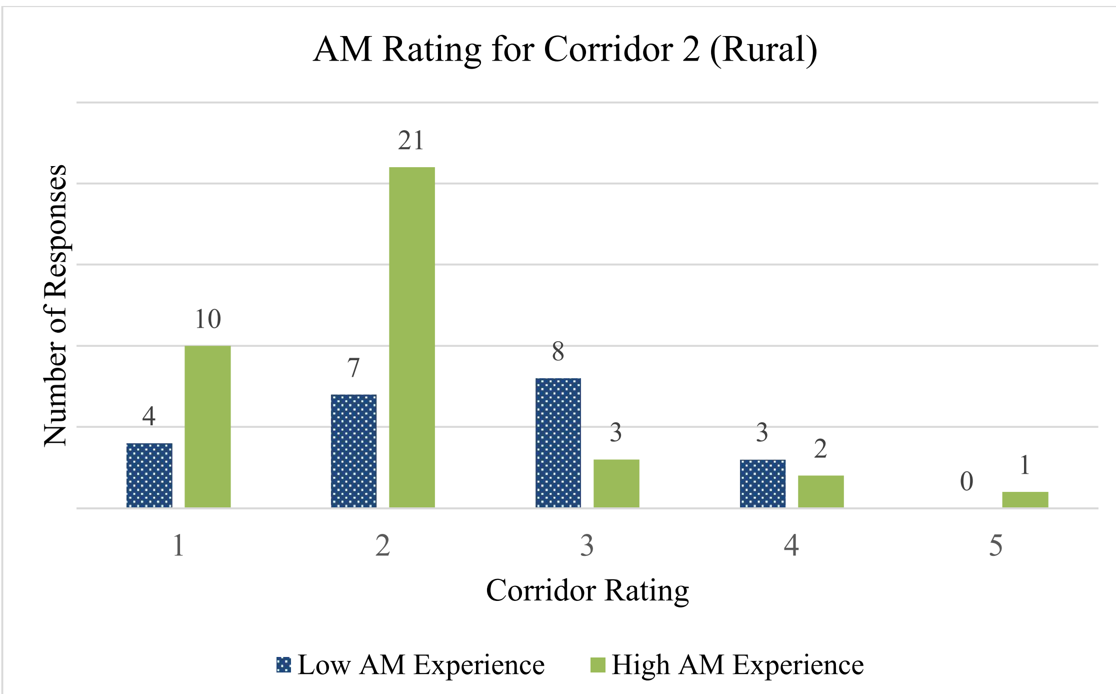


Figure 5. Survey Rating Results for Corridor 2

Corridor 3 was a six-lane urban arterial corridor with a raised median with strategic openings. The posted speed limit was 40 mph, the AADT was 12,000 vpd, and the corridor length was 0.35 miles. There were four restricted movement driveways, two full movement driveways, and three signalized intersections within the corridor extents. The survey rating results for Corridor 3 are shown on Figure 6.

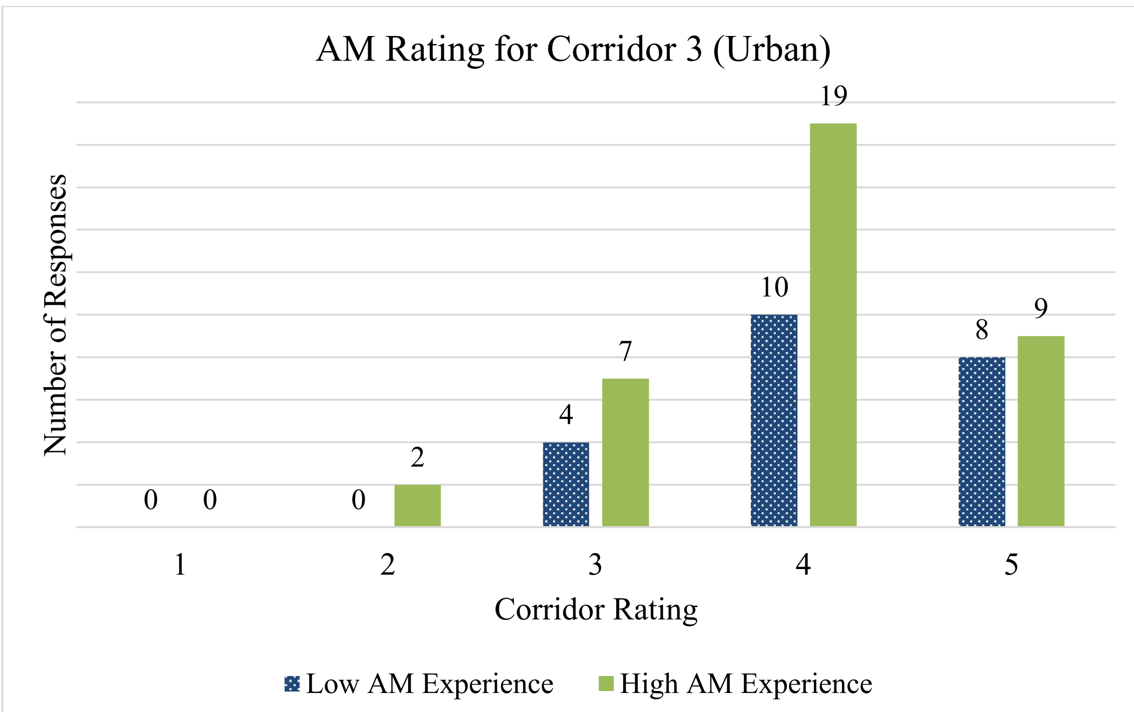


Figure 6. Survey Rating Results for Corridor 3

Corridor 4 was a rural two-lane highway with no median. The posted speed limit was 45 mph, the AADT was 12,000 vpd, and the corridor length was 0.50 miles. There were 10 full movement driveways and three stop-controlled intersections within the corridor extents. The survey rating results for Corridor 4 are shown on Figure 7.

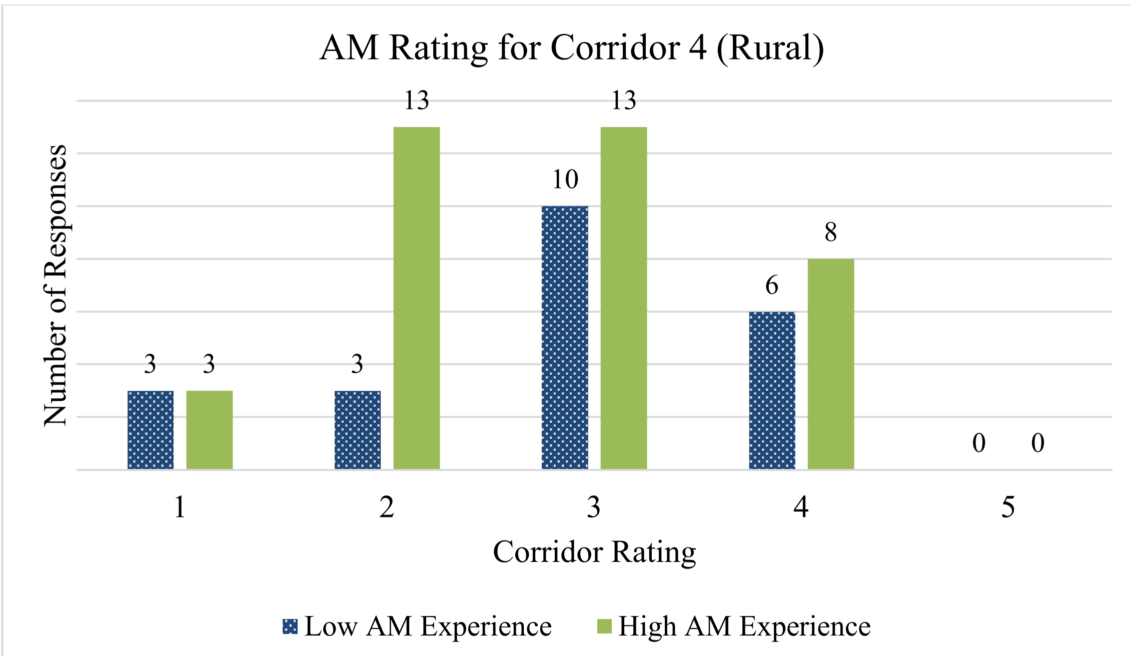


Figure 7. Survey Rating Results for Corridor 4

Corridor 5 was a five-lane urban arterial corridor with a center TWLTL. The posted speed limit was 40 mph, the AADT was 39,800 vpd, and the corridor length was 0.43 miles. There were two restricted movement driveways, five full movement driveways, four stop-controlled intersections, and two signalized intersections within the corridor extents. The survey rating results for Corridor 5 are shown on Figure 8.

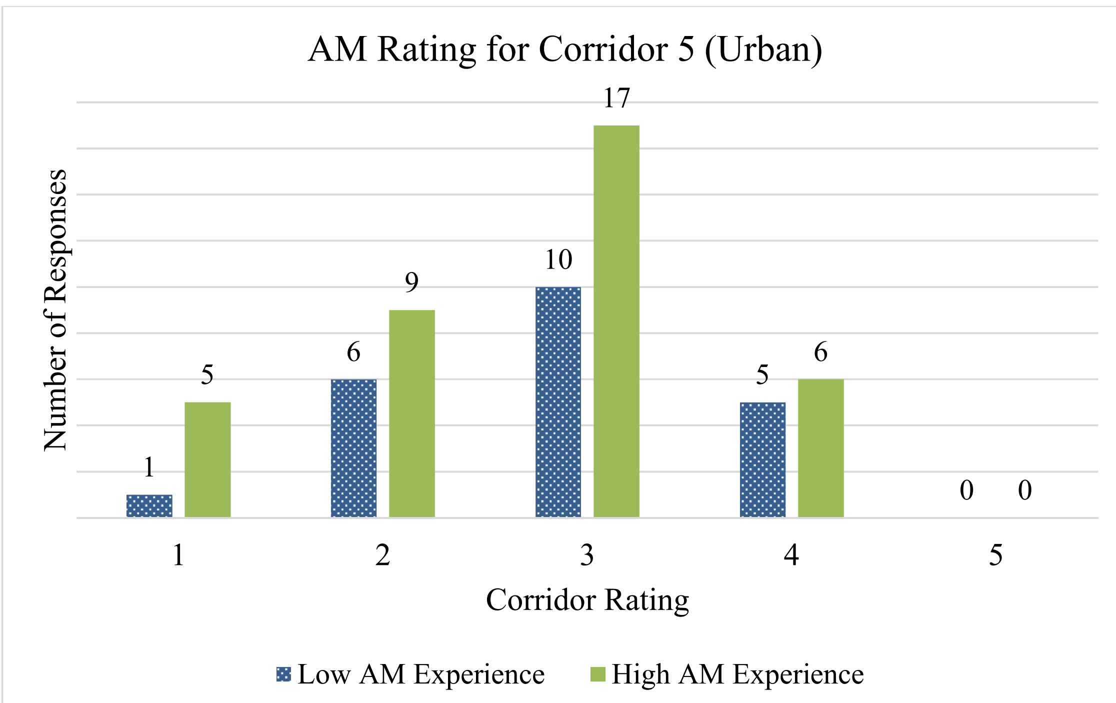


Figure 8. Survey Rating Results for Corridor 5

Corridor 6 was a six-lane urban arterial corridor with a painted median with strategic openings that transitioned into a center TWLTL. The posted speed limit was 40 mph, the AADT was 10,000 vpd, and the corridor length was 0.41 miles. There were nine restricted movement driveways, 14 full movement driveways, two stop-controlled intersections, and two signalized intersections within the corridor extents. The survey rating results for Corridor 6 are shown on Figure 9.

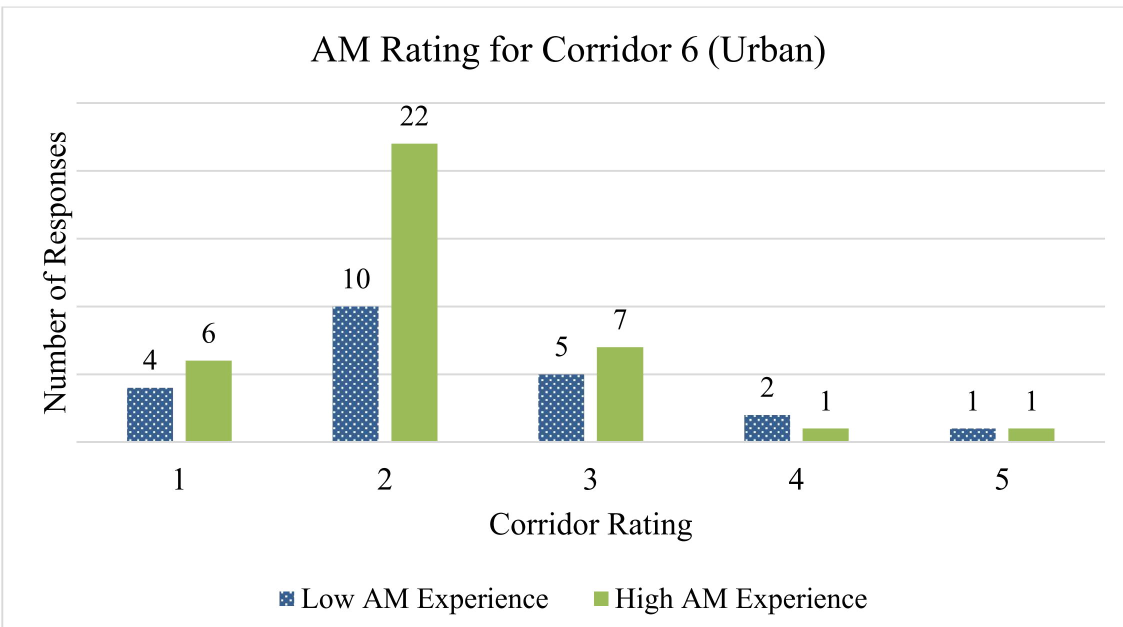


Figure 9. Survey Rating Results for Corridor 6

As shown on Figure 4 through Figure 9, half of the corridors received every rating possible, while the other half received four out of five possible ratings. This highlights the inconsistent nature in which access management is currently evaluated.

The ratings from participants with “high” access management experience tended to be slightly more clustered around a peak than the responses from participants with “low” experience. This trend suggests that as the level of understanding of access management principles increases, the evaluations may become more consistent. However, the survey results clearly show that even within a group of access management experts, evaluations vary significantly due to the level of subjectivity involved and the wide array of factors which can impact access management.

In addition to selecting a rating for each corridor, the survey also asked participants to identify the factors that most influenced their rating selection. More participants selected driveway density and spacing than any other factor on all six corridors. For the four urban corridors, median type was the second most selected variable, while the second choice for rural sites varied between land use, site development, and traffic volume. One possibility for this difference is that the two rural sites had no median, while all urban sites had some type of median present. While a lack of a median is a major consideration in the safety and operations of a corridor, participants might have ignored that option after assuming median type was only relevant if a median was present. This behavior carried over to other factors, as well. For example, the inclusion of transit facilities on a corridor is typically seen as a positive aspect of access management (assuming the facilities are properly designed and implemented), and therefore a lack of transit would be seen as a negative factor. However, “transit facilities” was not selected as an important factor for any of the sites where transit was not obviously present. Conversely, it was identified by seven respondents as an important consideration for the one site where a bus stop was clearly visible on the corridor photography. This pattern in the survey responses suggests that roadway characteristics which were obvious and visible had a larger impact on the corridor ratings than non-visible characteristics, even if the lack of a certain consideration would also have a significant impact on the safety and operations of the corridor. A detailed summary of the selected factors for each corridor is included in the survey results report in Appendix B.

Summary of Survey Results

The author utilized an online survey of 59 transportation professionals to investigate the standard of practice in evaluating access management along a corridor. The survey results highlighted the high level of subjectivity and variability involved in evaluating access management on a large scale. Because there are numerous factors known to affect access management to some degree, and each person has his or her own impression of the importance of each factor, access management evaluations will continue to be inconsistent unless a quantitative methodology is developed. Providing a means to objectively evaluate access management will enable practitioners to greatly improve the consistency in which corridors are planned, designed, retrofitted, and managed.

CHAPTER V

DATA COLLECTION AND REDUCTION

The data collection effort included infrastructure information (lane geometry, traffic control, etc.), interchange and corridor operations data (travel time, queue lengths, and traffic volume), and safety performance data (historical crash records). All of the data variables collected at each site are summarized in Appendix C. The NCHRP project team directed the collection and reduction of the field data including site selection, data collection methods, and data reduction.

Site Selection

The study sites consisted of 16 interchange locations in five different states, consisting of seven unique interchange types. Table 6 summarizes these sites.

Table 6. Summary of Data Collection Locations

Interchange Type	State	Interchange Site Code
Diamond, Signalized *	Arizona	AZ 1
Diamond, Signalized *	Arizona	AZ 2
Diamond, Signalized *	Arizona	AZ 5
Diamond, Signalized, with yield/free right turns *	Arkansas	AR 3
Diamond, Signalized, with yield/free right turns *	Arkansas	AR 4
Diamond, Signalized, with yield/free right turns **	Texas	TX 1
Diamond, Signalized, with yield/free right turns *	Texas	TX 2
Diamond, Stop Controlled *	Arkansas	AR 2
Diamond, Stop Controlled **	Virginia	VA 2
Diamond, Stop Controlled **	Virginia	VA 3
Single Point Urban Interchange (SPUI) *	Arizona	AZ 3
SPUI **	Arizona	AZ 6
Partial Cloverleaf (ParClo) *	Arkansas	AR 1
ParClo *	Virginia	VA 1
Roundabout	Arizona	AZ 4
Diverging Diamond Interchange (DDI)	Missouri	MO 1
* Denotes locations included in the operations and safety analysis. ** Denotes locations included in the survey of practitioners.		

In addition to varying geographic location and interchange type, the data collection sites represent a wide variety of conditions relating to signal density, access point density, land use type, and traffic volume. At most sites, the nearest signalized intersection served as the endpoint for data collection. For locations that did not include a downstream signalized intersection, or where the signalized intersection was a significant distance from the interchange, the project team selected an unsignalized intersection or driveway as the data collection endpoint. As such, study corridor lengths on each side of the interchange varied from 0.08 miles to 0.46 miles. Appendix C includes detailed information about each of the 16 sites.

Corridor Operations Data

The operations data collected at each study site consisted of traffic volume, queue lengths, travel time and vehicle speeds, and signal timing information. The procedures for collecting and reducing the data, as well as errors and limitations of the data, are described below.

Data Collection Procedures

The collection of operations data for each study site required the installation of stationary video cameras to capture traffic volumes and queue lengths, as well as in-vehicle travel time runs to capture corridor speeds.

At a minimum, field data collection included one hour of peak conditions and one hour of off-peak conditions at each site. At the AR-4 site, a severe thunderstorm limited data collection to 1.5 hours during afternoon peak traffic conditions. At the remaining sites, data collection spanned between four and eight hours. Due to the schedule and budget constraints of the project, data collection was limited to a single day at each location. While one day of data collection cannot capture long-term traffic patterns and fluctuations, the project team made a concerted effort to select days and times for data collection that would represent typical workday traffic characteristics as closely as possible.

Stationary video cameras captured turning movement volumes for the study interchange terminals, adjacent major intersections, and all access points within the study extents. The video data also captured queue lengths for the approaches to the interchange terminals and the adjacent signalized intersections. Cameras were mounted to available infrastructure (non-breakaway sign posts, street lights, pedestrian fences, etc.) and thus could not be placed at consistent locations between sites. Some sites required 11 cameras to capture the corridor extents and all access points, while other sites required only four cameras.

During the same time periods as the stationary video data collection, the project team conducted multiple travel time runs to capture corridor operating speeds. The data collection equipment for the travel time study included a video camera mounted on the dashboard, a GPS unit, and a laptop installed with software that automatically recorded a time stamp and GPS coordinates every tenth of a second. Whenever possible, the team members selected a random vehicle and used the traditional car-following method for travel along the corridor, maintaining a consistent distance between them and the subject vehicle. However, when high turning volumes limited the ability to follow a single vehicle through the entire corridor, the team members instead used the floating car method where they kept speed with prevailing traffic and passed the same number of vehicles as passed them. Travel time runs extended to at least one major intersection past the study corridor extents to ensure accurate readings throughout the entire study corridor.

Lastly, local agencies provided signal timing plans for the interchange terminal intersections when possible. The video data allowed for verification and adjustment to the provided signal timing based on actual field conditions. When signal timing plans were not available, team members used the available video data from both the stationary video cameras and the travel time runs to estimate the signal timing parameters.

Data Reduction Procedures

The project team reduced the video and travel time data to obtain traffic volumes, queue lengths, travel times, and travel speeds for the 16 study locations. Team members summarized traffic volumes in five-minute intervals and recorded maximum queue lengths in one-minute intervals.

The travel time studies provided total travel time and distance information between pre-determined points along the study corridor. For all 16 interchange locations, the project team divided the corridor into four sections for travel time and speed summaries, as shown on Figure 10.

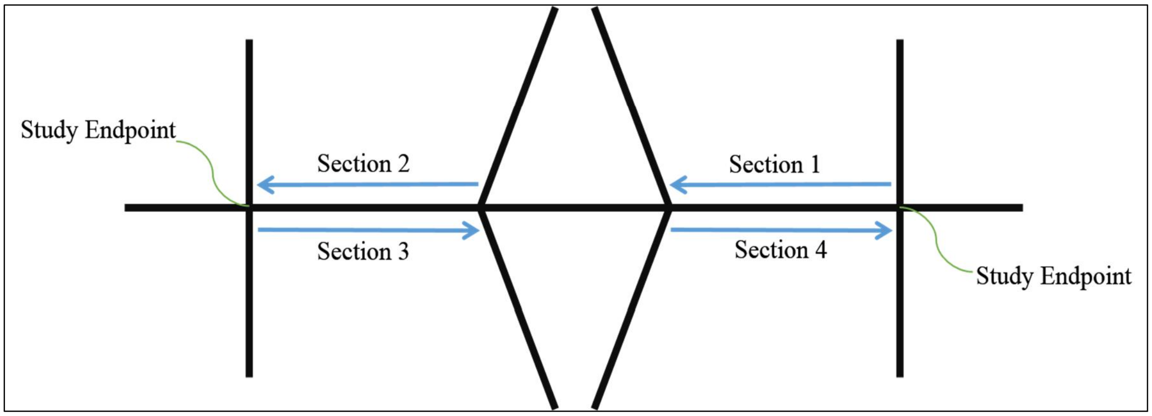


Figure 10. Travel Time Sections

For each section, the project team calculated the average travel time of all runs during a consistent time period (peak or off-peak traffic conditions), and then used the section lengths to calculate the average travel speed.

Data Errors and Limitations

The reduction of the data revealed several errors and limitations of the field data collection effort, as summarized below:

- As previously mentioned, a severe thunderstorm and subsequent equipment malfunction limited data collection to only 1.5 hours during peak traffic conditions at the AR-4 site.
- The most significant limitation during the data collection effort was the number of video cameras and the limited recording time (due to battery life) for each camera. With six to eight cameras at each location and batteries that had to be switched every two to four hours, there were many

instances when a camera battery died before a team member could replace it, resulting in a gap in video data. As a result, the hours of complete video data for the entire corridor was often less than the six to eight hours of data collection (all cameras had to be operating simultaneously to provide useful data).

- Because hourly corridor traffic volumes were not available prior to the data collection effort, the project team estimated when the peak and off-peak traffic conditions would occur based on adjacent land use and logical traffic patterns. However, after reducing the traffic volume data, the project team noticed that the actual peak and off-peak hours did not always coincide with estimates.
- As a result of the issues in the previous two bullet points, the travel time runs did not always coincide with the hours of continuous traffic count data. This primarily affected the simulation validation effort and is discussed in further detail in Chapter VI.

Corridor Safety Data

The safety data collected for each study site consisted of historical crash data, either in the form of individual crash reports or crash databases. The procedures for collecting and reducing the data, as well as errors and limitations of the data, are described below.

Data Collection Procedures

State and local agencies provided a minimum of three years of historical crash data for each of the study corridors. The principal investigator of the NCHRP project ensured that all sensitive and identifying information was redacted from the crash data before sharing it with members of the project team for reduction.

Data Reduction Procedures

Each state and local jurisdiction has a different method for collecting and reporting crash data. Some agencies provided copies of actual crash reports that were redacted of personal information, while other agencies provided a summary database of crash details.

Project team members investigated each crash and used any available location information to verify that the crash actually took place within the study corridor limits. From there, team members developed summary tables and collision diagrams detailing the location, date, type, and severity of each crash. Summarized crash data is included on the site information sheets presented in Appendix C.

Data Errors and Limitations

The following points summarize the limitations associated with the collected safety performance data:

- First, each jurisdiction records different crash details in their database. Because this dissertation is focused on access management, identifying crashes related to driveways and access points would have been particularly useful. Unfortunately, this type of information is not typically recorded. As a result, the author could only estimate the number of driveway-related crashes based on crash type and approximate crash location.

- Second, each jurisdiction also implements different procedures for reporting crashes, particularly with regards to minimum damage thresholds for reporting property damage only (PDO) crashes. As a result, the total number of crashes (which includes PDO) are typically not comparable between different states without first making adjustments for reporting thresholds.

Summary of Data Collection

The author collected operations and safety data at 16 interchange locations in five states. The operations data included roadway geometry characteristics, traffic volume, corridor travel time, queue lengths, and signal timing parameters. The collected safety data included three years of historical crash data. This data served as the basis for analyzing the impacts of access management, as described in the following chapter.

CHAPTER VI

ANALYSIS OF ACCESS MANAGEMENT IMPACTS

In order to develop an accurate methodology to evaluate access management along a corridor, the various impacts of access management strategies must first be well understood. While the existing literature provides a solid foundation of knowledge on the impacts of access management, much of the information is focused on isolated relationships that do not provide a clear picture of the combined impact of multiple access management techniques on operations and safety. The purpose of the analyses described in the following sections was to gain an understanding of the comprehensive impacts of access management on urban arterial corridors.

As described in Chapter V, the data collection effort included a total of 16 interchange locations in five states. The author excluded sites with unique traffic control (the roundabout terminals and diverging diamond interchange), and also reserved four sites for inclusion in the survey and validation of the final methodology. The remaining ten sites included in the operational and safety analyses are shown in Table 7.

Table 7. List of Sites Used for Safety and Operational Analyses

Interchange Site Code	State	Interchange Type
AR 1	Arkansas	Partial Cloverleaf
AR 2	Arkansas	Stop Controlled Diamond
AR 3	Arkansas	Signalized Diamond
AR 4	Arkansas	Signalized Diamond
AZ 1	Arizona	Signalized Diamond
AZ 2	Arizona	Signalized Diamond
AZ 3	Arizona	SPUI
AZ 5	Arizona	Signalized Diamond
TX 2	Texas	Signalized Diamond
VA 1	Virginia	Partial Cloverleaf

Analysis of Operational Impacts

The author conducted all operational analyses using the traffic microsimulation software package VISSIM (Version 7.0). The details of the operational analyses, including base model development and validation, characteristics of alternative scenarios, regression analysis, and key findings are described below.

VISSIM Model Development and Validation

The author developed a VISSIM model of each of the ten sites shown in Table 7. In order to ensure the models accurately represented the roadway geometry of each site, aerial photography served as the base layer of each model. The acquired field data described in Chapter V provided the remaining inputs for each model, including roadway and driveway traffic volumes, traffic signal timing, traffic composition (percentage of heavy vehicles and passenger cars), and posted speed limits. When traffic volumes and signal timing data were available for both peak and off peak time periods, the author developed two separate models representing each set of conditions.

The project team counted individual vehicles and summarized the traffic volumes in either five-minute or fifteen-minute intervals for each site. VISSIM allows for traffic volumes to be entered for any time interval, with hourly volumes being easiest to program. Because the validation effort was to be based on isolated travel time runs over an entire hour, and also because of the large number of required VISSIM models, the author elected to use hourly volumes instead of smaller intervals. However, since VISSIM does not include a mechanism to directly input a specific peak hour factor (PHF), the simulations relied on the built-in traffic flow variation within VISSIM to capture peaking characteristics. Table 8 summarizes the calculated peak hour factors from the traffic count data and the observed peak hour factors from the simulation runs for three different sites. As shown, the PHFs are relatively similar and the author is confident that the simulations captured appropriate peaking characteristics despite using hourly traffic volumes.

Table 8. Comparison of Actual and Simulated Peak Hour Factors

Interchange Site Code	**Interchange Type**	**Actual PHF Range**	**Simulated PHF Range**
AR 3	Signalized Diamond	0.92 – 0.98	0.89 – 0.98
AZ 3	SPUI	0.84 – 0.92	0.90 – 0.98
AR 2	Stop Controlled Diamond	0.88 – 0.94	0.89 – 0.96

The base models were first validated using operational data collected in the field, after which they were adjusted to evaluate different infrastructure and traffic volume alternatives. The following sections describe these efforts in detail.

Base Model Validation

After the development of each model, the author used segment travel time (essentially, a measure of space mean speed) as the basis for model validation. In order to deem a model as validated, the author required the average travel time reported in VISSIM to be within two standard deviations of the travel time acquired in the field. This requirement applied to four separate travel time segments per site, as previously shown on Figure 10 in Chapter V. The author took the most conservative approach and validated the models using standard deviations calculated from the simulated data, as shown in Equation 2.

Equation 2. VISSIM Travel Time Validation Equation

$$\left|TT_{field} - TT_{simulation}\right| \leq 2\sigma_{simulation}$$

where:

TT_{field}	=	Field data travel time
$TT_{simulation}$	=	Simulated travel time
$\sigma_{simulation}$	=	Standard deviation of simulated travel time data

The standard deviation of the simulated data is automatically generated by VISSIM and is calculated using the travel time measurements of all simulated vehicles in a one-hour period, averaged over the 10 simulation runs. In cases where the standard deviation of the simulated data was very small (less than 0.50 seconds) and achieving validation was not feasible, the author ensured the difference was within two standard deviations of the field data (based on anywhere from two to 10 travel time measurements). While using the field data standard deviation was much less conservative due to the small sample size, validation using this approach applied to no more than one travel time segment per model. More detailed information on the results of the validation effort is included in Appendix D.

As briefly mentioned in Chapter V, the time periods resulting in peak and off-peak traffic volumes did not always coincide with the times of the field acquired travel time runs. As a result, the author did not have enough data to validate both peak and off peak models for some sites. Table 9 summarizes the successfully validated models for each site.

Table 9. Successfully Validated Models for Study Sites

Interchange Site Code	Traffic Conditions of Validated Models
AR 1	Peak and Off Peak
AR 2	Peak Only
AR 3	Peak and Off Peak
AZ 1	Peak Only
AZ 2	Peak and Off Peak
AZ 3	Peak Only
AR 4	Peak Only
AZ 5	Peak and Off Peak
TX 2	Peak and Off Peak
VA 1	Peak and Off Peak

In order to attain validation, the author adjusted several characteristics of each model. The most commonly adjusted characteristic was the signal timing offset between signalized intersections which significantly impacted corridor progression, and thus travel time. For sites with heavy truck traffic, the author adjusted the percentage of heavy vehicles to match field conditions, and also adjusted the acceleration and deceleration characteristics to more accurately represent real world driving behavior. At some sites, field data indicated that the traffic stream consistently traveled at a speed different than the posted speed limit. This may have been due to sun glare, weather conditions, roadway grade, or any number of unknown factors. When appropriate, the author adjusted the roadway speed limit within the simulated network to better represent the travel speeds observed in the field.

<u>Alternative Scenarios</u>

The author investigated the effects of different access management strategies by using the validated base models to develop several alternative scenario models for each site. The models varied by median type, access point density, signalized intersection spacing (when applicable), and the spacing between signalized intersections and driveways. Table 10 summarizes the different alternative conditions analyzed for each access management factor.

Table 10. Access Management Conditions Included in Alternative Scenarios

<table>
<tr><th>Factor</th><th colspan="6">Conditions Analyzed</th></tr>
<tr><td>Median Type</td><td>None</td><td colspan="2">TWLTL</td><td colspan="2">Raised (Continuous)</td><td>Raised (Strategic)</td></tr>
<tr><td>Access Point Density</td><td colspan="3">Low (20 access points per mile)</td><td colspan="3">High (40 access points per mile)</td></tr>
<tr><td>Signal Spacing</td><td colspan="2">Low (< 500 feet)</td><td colspan="2">Medium (1,320 feet)</td><td colspan="2">High (> 2,640 feet)</td></tr>
<tr><td>Signal-Driveway Spacing</td><td colspan="2">Low (< 200 feet)</td><td colspan="2">Medium (300-500 feet)</td><td colspan="2">High (> 1,000 feet)</td></tr>
</table>

The alternative scenario development did not include changing the number of lanes as this would significantly alter the functionality of the corridor. Once the base functionality of the corridor is changed, it is no longer accurate to claim that the model is validated against field conditions. Although the author did not vary the number of lanes in the alternative scenario development, the base conditions of the ten sites included two, three, four, five, and six lane cross-sections. In addition to infrastructure alternatives, the author also analyzed each alternative scenario model under varying levels of traffic volume. The exact volume scenarios varied depending on the characteristics of each site, and the author used either a segment LOS of F (based on HCM calculations) or a report of more than 50 vehicles not being analyzed in the simulation as the threshold for determining a maximum analysis volume. When operations degrade, queues may extend beyond the extents of the simulated network which restricts the number of vehicles that can enter the network. If the number of vehicles unable to enter the network is significant (in this case, 50 or more vehicles), the number of processed vehicles will not equal the number of programmed vehicles; thus, the operations results will not accurately represent the programmed traffic volume levels.

The author estimated that investigating all possible combinations of alternatives for each site would require more than 600 days of active simulation time (based on the computing power available), which was not feasible. Instead, the author attempted to model a representative set of conditions that captured a wide array of combinations that are commonly implemented in the field (e.g., the analysis did not include a roadway with a six lane cross-section and no median). Across the ten study sites, the author developed approximately 400 VISSIM models representing different combinations of site characteristics, access management factors, and traffic volume. Because each side of the interchange represented a different set of characteristics, the 400 models provided approximately 800 unique data points.

Simulation Parameters

The following list summarizes the parameters and assumptions that apply to all simulation scenarios:

- Each data point is the average of ten unique simulation runs, seeded with random numbers ranging from 15 to 205.
- All simulations were 3,900 seconds in duration, providing 300 seconds (five minutes) of network seeding time and 3,600 seconds (one hour) of simulated data collection. FHWA's Traffic Analysis Toolbox suggests a minimum seeding time equal to (or greater than) twice the free-flow travel time from one end of the network to the other. The maximum observed field travel time during peak traffic conditions was 120 seconds (two minutes), requiring a minimum seeding time of 240 seconds or four minutes.
- Travel time and speed measurements reported in this chapter are the average of all vehicles traveling along the defined roadway segment, averaged over the ten simulation runs.

Operational Regression Analysis

The database of operations data consisted of two types of data points – those from the validated base conditions models (providing 32 data points) and those from the developed alternative scenarios (providing 774 data points). Initially, the author intended to analyze these two data types separately since extra explanatory variables (e.g., land use) were available for the validated models which were based on actual locations. Additionally, the possibility of using a different response variable (e.g. speed change relative to base conditions) was available for the alternative scenario data. However, after exploring the data and conducting initial regression analyses, the two individual data sets yielded results that were very similar to the combined data set. The author also investigated using an indicator variable for validated or non-validated sites as part of the full data set, but the analysis indicated such a variable was not significant. As a result, the author elected to combine all 806 data points into a single data set for analysis purposes.

Urban versus Rural Locations

The full operations dataset included both urban and rural data points. Upon initial investigations, the author observed that the average speed for the rural corridors was noticeably higher than for the urban corridors. The higher operating speed was due to two primary factors. First, all of the rural data points were based on a single rural location that had a posted speed limit of 55 mph (15 mph higher than average posted speed on the urban corridors). In addition, the rural interchange location was a stop-controlled diamond that did not include any traffic signals. Since the average corridor speed includes signal delay, and all other sites included at least one signal, the speed values at the rural site were inflated. Because the rural data points provided results that were unique from the rest of the data set, and because the rural data was based on only a single study location, the author elected to remove the rural site from the data set. As a result, the operations component of the AMAT is applicable only to urban locations. To maintain consistency within the AMAT procedure, the author also excluded rural considerations from the safety and accessibility components.

Data Variables

The author selected average corridor speed (averaged in both directions for the entire length of the segment) as the response variable for the regression analysis. The model development and selection effort investigated the significance of the following explanatory variables (the asterisk (*) indicates variables that were only available for validated base conditions):

- Posted Speed
- Median Type
- Interchange Type
- Distance between Signals
- Corridor Length
- Access Density
- Roadway Volume (vph)
- Number of Lanes
- Volume per Lane (vphpl)
- Validated Site Indicator
- Interchange Corner Clearance
- Urban/Rural Indicator
- Percent Full Movement Driveways
- Percent Commercial Land Use*
- Percent Residential Land Use*
- Percent Vacant Land Use*
- Percent Developed Land Use*
- Driveways Per Parcel*
- Interactions of:
  - Posted Speed & Median Type
  - Median Type & Volume
  - Access Density & Median Type

Table 11, Table 12, and Table 13 summarize the characteristics of the final urban data set, which included 770 data points. A Pearson's correlation table is also presented in Table 14.

Table 11. Operations Data Characteristics by Variable

Variable	Minimum Value	Median Value	Maximum Value
Distance to Signal (feet)	400	1,320	5,999
Signal Cycle Length (seconds)	95	130	180
Access Density (per mile)	19	30	102
Hourly Volume (vph)	700	2,300	5,500
Daily Volume (vpd)	12,150	40,500	104,400
Hourly Volume per Lane (vphpl)	133	467	925
Number of Lanes	4	4	6
Posted Speed (mph)	35	40	50
Average Operating Speed (mph)	6	23	37

Table 12. Number of Operations Data Points by Median Type

Median Type	Number of Data Points
Raised, Continuous	206
Raised, Strategic	250
TWLTL	332

Table 13. Number of Operations Data Points by Interchange Type

Interchange Type	Number of Data Points
Signalized Diamond	306
Signalized Diamond with Channelized Right Turn Lane	224
Parclo	176
SPUI	64

As shown in Table 12, the analysis included more TWLTL medians than any other median type, which is representative of the field conditions at the study locations. Similarly, the relative number of data points by interchange type (Table 13) was dictated by the field conditions at the study locations. The most represented interchange type was a typical signalized diamond, followed by a signalized diamond with channelized right turn lanes, a partial cloverleaf, and finally a SPUI.

Table 14 presents the Pearson's correlation coefficients for key variables, including posted speed, signal spacing, access density, traffic volume, and median type. Pearson's correlation coefficients range from negative one to positive one. Values further away from zero indicate a higher level of linear correlation between the two variables. In general, a value near 0.5 indicates a moderate level of linear correlation.

Table 14. Pearson's Correlation Table for Key Variables

Variable	Posted Spd	Sig Spacing	Access Density	vphpl	Avg Spd	Med_ TWLTL	Med_ RS	Med_ RC
Posted Spd	1.000	-0.292	-0.158	0.116	0.204	-0.378	0.195	0.213
Sig Spacing	-0.292	1.000	-0.061	-0.231	0.222	-0.096	0.287	-0.197
Access Density	-0.158	-0.061	1.000	-0.032	-0.056	0.177	-0.137	-0.052
vphpl	0.116	-0.231	-0.032	1.000	-0.070	0.318	-0.242	-0.097
AvgSpd	0.204	0.222	-0.056	-0.070	1.000	0.006	-0.008	0.002
Med_ TWLTL	-0.378	-0.096	0.177	0.318	0.006	1.000	-0.575	-0.502
Med_RS	0.195	0.287	-0.137	-0.242	-0.008	-0.575	1.000	-0.419
Med_RC	0.213	-0.197	-0.052	-0.097	0.002	-0.502	-0.419	1.000

The relatively high values (greater than 0.5) shown in Table 14 for combinations of different median types are simply a result of a multi-level variable. Because a data point can only be associated with one median type, and when one median type is present all others are not, there is inherent correlation between median type levels. Excluding the coefficients for combinations of different median types, the coefficient values do not indicate anything other than weak linear correlations between variables and therefore do not warrant further consideration in the modeling approach.

Modeling Approach

Because the final urban data set consisted of 770 data points from only nine unique study locations, the data could not be analyzed under the assumption of independence. To account for this, the author utilized a mixed-effects modeling approach using a categorical variable identifying the study site as a random effect.

Throughout the model development and selection process, the author calculated the intraclass correlation coefficient (ICC), which is often used to evaluate correlation between variables, and thus is a measure of whether a mixed effects model is appropriate. The ICC is a ratio of the variance explained by the random effects divided by the total variance. Using a mixed-effects model is typically assumed to be appropriate when the ICC is greater than approximately 0.4 or 0.5. For all of the models tested in the operations data analysis, the ICC ranged between 0.67 and 0.75, indicating that the modeling approach was valid.

The model quality criteria Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) served as the primary basis for model selection, supplemented by analysis of variance (ANOVA) comparisons. For all models tested, the author also confirmed assumptions of equal variance and normality using residual plots and the symmetry of the scaled residuals.

Model Development and Selection

As discussed previously, the basis for model selection was a combination of AIC, BIC, ANOVA comparisons, and graphical investigations of the data. After investigating numerous combinations of variables, two models clearly stood out as the best predictors of average corridor speed while excluding unnecessary (insignificant) variables:

Model 1:

AvSpeed = f(MedianType + DistancetoSignal + vphpl)

Model 2:

*AvSpeed = f(DistancetoSignal + MedianType * vphpl)*

As shown, the two models include the same three predictor variables relating to signal spacing, median type, and traffic volume per lane. The key difference is the interaction between median type and volume included in Model 2. An ANOVA comparison of the two models indicated a statistically significant difference between the two, even though the BIC value for both models was almost identical (Table 15).

Table 15. ANOVA Comparison of Operations Regression Models

	Degrees of Freedom (df)	**AIC**	**BIC**	**Log Likelihood**	**Test**	**L.Ratio**	**p-value**
Model 1	7	4158.4	4190.9	-2072.2			
Model 2	9	4142.8	4191.1	-2062.4	1vs2	19.586	0.0001

The residual plots for both models are also very similar, as shown on Figure 11 and Figure 12.

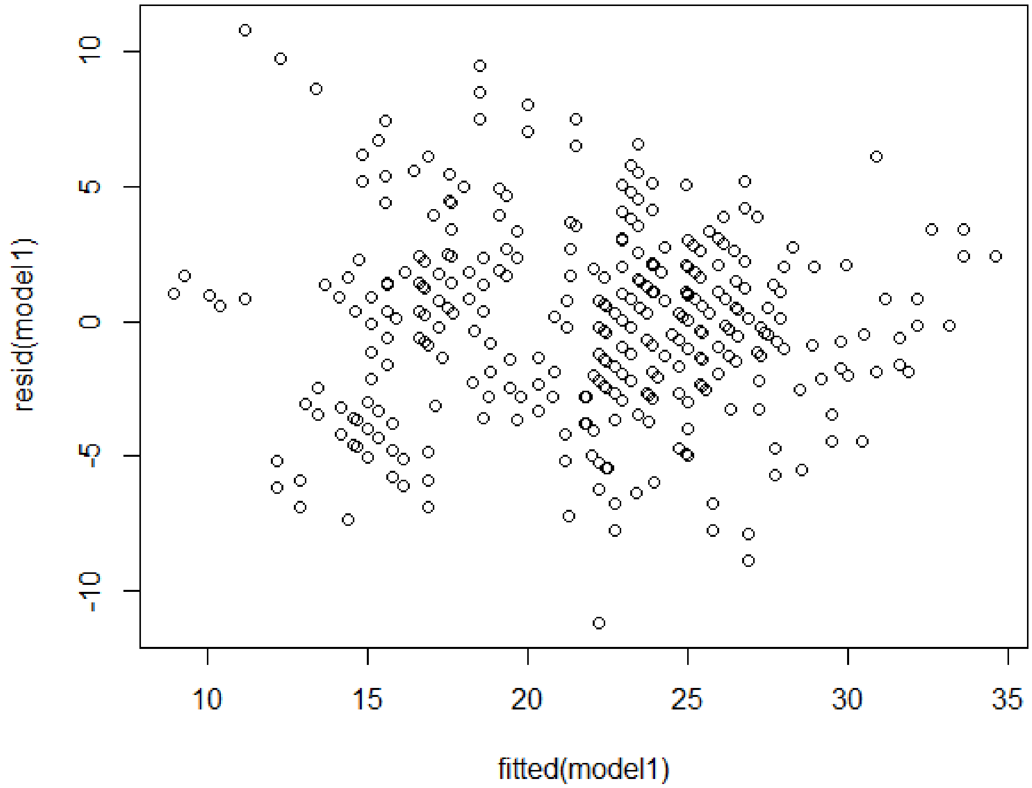


Figure 11. Fitted versus Residual Values for Model 1

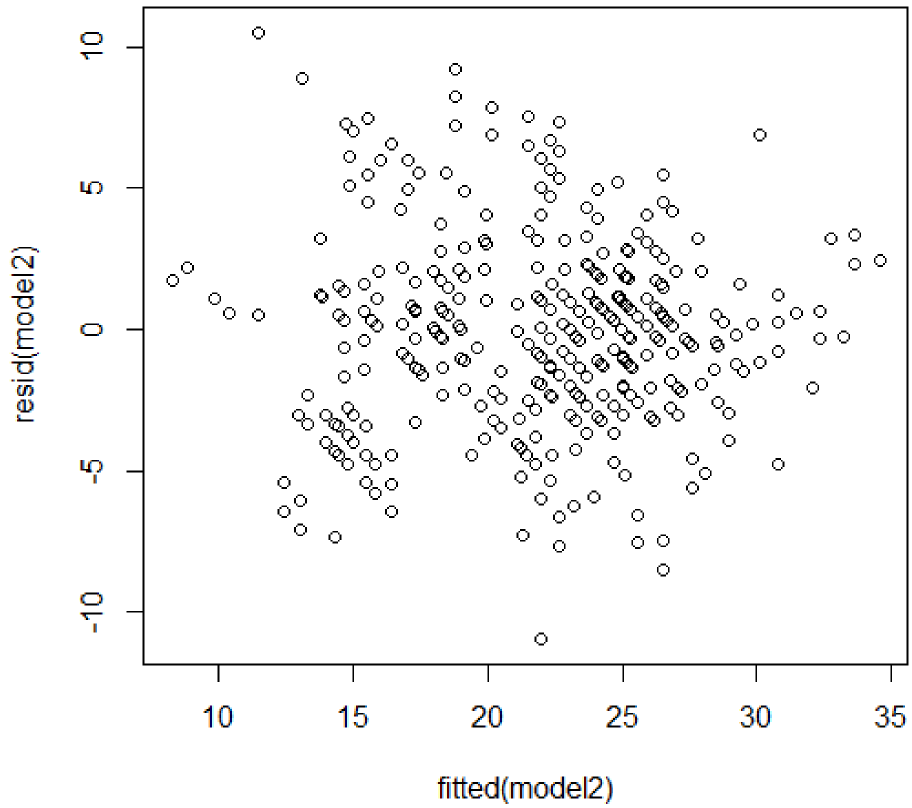


Figure 12. Fitted versus Residual Values for Model 2

The interaction plot for median type and volume per hour per lane is shown on Figure 13. Within each median type, very few of the lines actually have intersecting slope patterns, which indicates only a small level of interaction between the three variables. Additionally, because there were only certain combinations of median type and volume, the data used to create the interaction plot is not continuous, resulting in gaps and unlikely trends between data points.

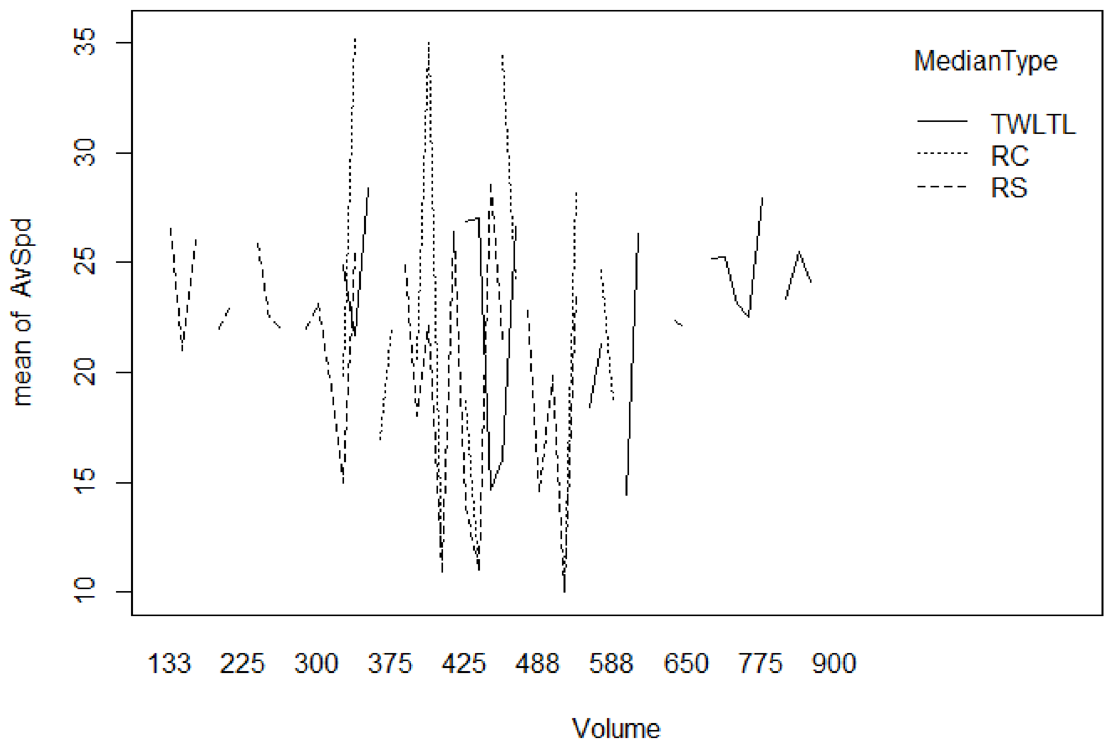


Figure 13. Interaction Plot of Volume, Speed, and Median Type

Because none of the above information provided indisputable evidence for one model over the other, the author elected to use the simpler model without the interaction term. Additionally, the parameter estimates of the selected model served as the basis for creating a much more general zero-to-five scale, and thus minor differences in model estimates would not have a substantial effect on the end product of this dissertation. The author verified this assumption by running calculations for one median type and signal density (across all volume levels) using both sets of models, and the resulting zero-to-five rating scale did not differ.

Key Findings of Operations Investigation

Of the 20 explanatory variables investigated, only three were determined to be significant based on the regression analysis results. The average speed prediction equation from the best-fit model for corridor operations is shown in Equation 3, and the model details are shown in Table 16.

Equation 3. Average Speed Prediction Equation from Best Fit Model

$$AvgSpeed = 28.63 - 4.144(RSMedian) - 2.766(TWLTL) + .002(Dsignal) - 0.015(vphpl)$$

where

$AvgSpeed$	=	Average Corridor Speed (mph),
$RSMedian$	=	Indicator variable, value of 1 for strategic raised median, zero otherwise,
$TWLTL$	=	Indicator variable, value of 1 for TWLTL, zero otherwise
$DSignal$	=	Distance between signalized intersections (ft.), and
$vphpl$	=	Vehicles per hour per lane

Table 16. Summary of Corridor Operations Model with Respect to Average Speed

Fixed Effects	Estimate	Std. Error	p-value
Intercept	28.632	2.064	<0.0001
Median-Raised Strategic	-4.144	0.510	<0.0001
Median-TWLTL	-2.766	1.006	0.0061
DSignal	0.002	0.0001	<0.0001
vphpl	-0.015	0.001	<0.0001
Note: Median type estimates are relative to continuous raised median.			

The most surprising outcome of the regression analysis was that neither posted speed limit nor access density were significant predictors of corridor speed when median type was accounted for. For models that did not include median type, posted speed was a significant variable, but models with median type proved to be a better fit to the data. This suggests that median type, posted speed, and access density are all correlated to some degree, and median type is able to partially explain some of the impacts related to both of the other factors. Additionally, with regards to access density, it is probable that the signal operations along the corridor had a significantly larger impact on average speed than any access characteristics, and thus access-related factors were not significant. Lastly, it is worth noting that the average speed data includes all through lanes of traffic. If speed data were available on a per-lane basis and trends could be investigated for the right-lane only, it is possible more significant trends relating access density and speed could be observed.

Analysis of Safety Impacts

The author initially intended to conduct all safety analyses using the safety assessment software SSAM. The most significant benefit to using the SSAM software for the safety analysis effort was the ability to directly import an existing VISSIM model, thereby evaluating the exact same conditions in both safety and operational analysis efforts, and allowing for countless alternatives to be assessed. Unfortunately, after attempting to validate the SSAM results against actual crash data for three sites, it became apparent that the SSAM software was not accurately estimating the safety performance of the corridors. As such, the author revised the safety analysis approach to include a preliminary trend analysis and descriptive statistics of the safety performance of the study locations for which historical crash data was available. Although this resulted in a much smaller data set (20 data points with three years of data), the author is confident that the substantial body of literature on the topic, combined with the results of this analysis, will provide a solid base for the development of the AMAT.

The following sections describe the initial attempt at using the SSAM software, the revised safety analysis approach, and the results of the safety analysis.

Comparison of SSAM Results and Crash Data

The author evaluated three different study sites using SSAM and compared the results to three years of historical crash data. The SSAM estimated value for crashes per year is a conversion from observed conflict points within the VISSIM model to total crashes per year based on Equation 1 shown in Chapter II. Although the SSAM analyzed the entire VISSIM network, the resulting safety performance data includes only the study corridor within the study limits and excludes interchange ramps, side-streets, and driveways. Table 17 and Figure 14 summarize the tested sites, the SSAM estimated crashes per year using both peak and off-peak validated VISSIM models, and the actual number of crashes per year averaged over the most recent three years of data.

Table 17. Comparison of SSAM Results and Crash Data

Site Location	Interchange Type	Total Crashes Per Year		
		SSAM Estimates		*Crash Data (3-Year Average)*
		Off-Peak Hour Model	Peak Hour Model	
AR 2	Stop-Controlled Diamond	n/a	46	3
VA 1	Par-Clo	142	497	66
AR 3	Signalized Diamond	303	1,203	92

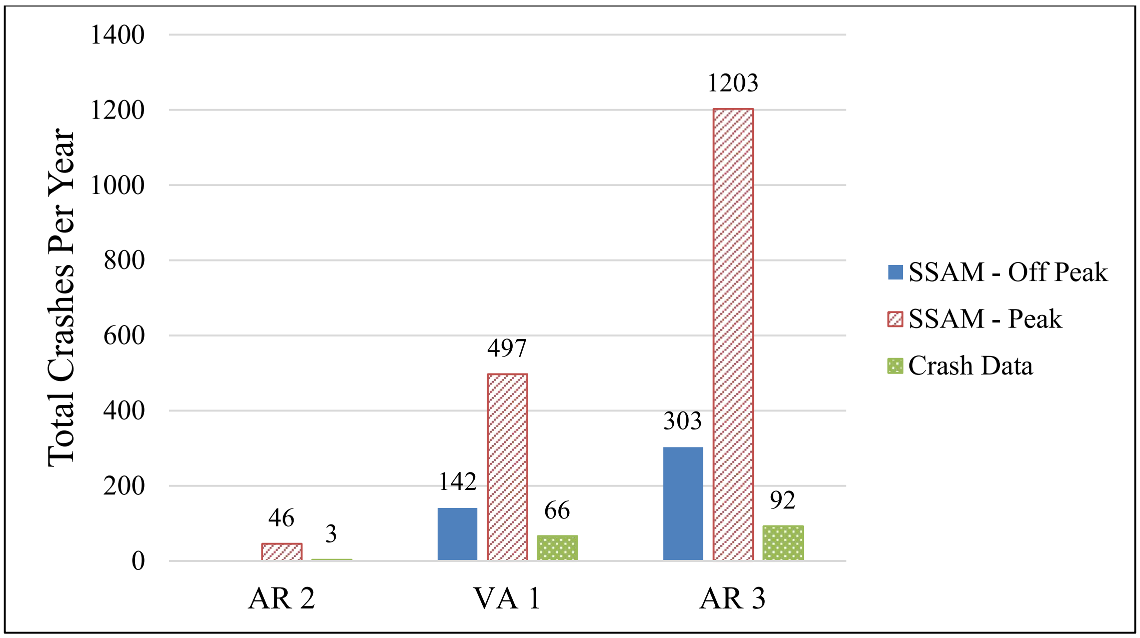


Figure 14. Comparison of SSAM Results and Crash Data

As shown in Table 17 and on Figure 14, the SSAM software significantly overestimated the number of crashes on all three corridors. While the off-peak hour models resulted in estimates closer to actual data than the peak hour models, the estimates were still two to three times higher than the reported number of crashes. In addition, there was no trend in the magnitude of overestimation for the three sites.

The discrepancy between the SSAM results and historical crash data could be due to a number of factors. First, the SSAM estimates are obviously very sensitive to traffic volume, and thus the time periods analyzed may not be suitable for estimating crashes per year. Secondly, the intricate modeling of the VISSIM network, including precise placement of links and connectors, appears to have a significant impact on the estimate of conflicts and crashes. Even though the models validated in terms of operational performance measures, there may be underlying design flaws in the creation of the VISSIM roadway networks that inflated the conflict estimates. Lastly, while the SSAM was developed using data from a wide array of corridors, it is possible that it is not suitable for analyzing the unique infrastructure and driver behavior characteristics associated with corridors in the vicinity of interchanges. Regardless of the precise reason for the inaccurate safety performance estimates provided by SSAM, the author decided that the discrepancy was too great to warrant a validation and calibration effort.

Safety Investigation

The data set for the safety analysis included the same 10 interchange locations used in the operations analysis. Since each side of an interchange included different roadway characteristics, the 10 locations provided 20 unique data points. (Although the operations analysis excluded the single rural location due to unique operational characteristics, the author retained the rural site in the safety investigation for information purposes only. The final dataset used to develop the safety component of the AMAT included only urban locations.) Local and state agencies provided three years of historical crash data for each site, with 2011-2013 providing the three most recent years of common data across all sites.

As with the operations analysis discussed previously, using regression analyses to evaluate the safety performance of the study corridors would require the use of a mixed effects model to account for the relation between each side of an interchange. Using this type of model would require a minimum of 100 data points (approximately 30 data points for each degree of freedom), which is significantly more data than was available for this research effort. As such, the author was constrained to rely on descriptive statistics and trend analysis to evaluate the safety performance data. This information, in conjunction with information provided in the HSM and findings of previous research, served as the basis for the development of the safety-based AMAT procedure.

Using collision diagrams developed by the NCHRP project team, the author estimated the total number of crashes as well as the number of driveway-related crashes at each site. For purposes of this dissertation, driveway-related crashes are defined as multiple-vehicle crashes in close proximity to a driveway, as estimated from location information included in the crash reports. As mentioned in Chapter V, each state has their own reporting thresholds for PDO crashes, and thus comparing either PDO crashes or total crashes among different states is not recommended. Therefore, the author focused on fatal and injury (FI) crashes for the safety analysis effort. Table 18 summarizes the three-year total number of crashes, averaged by median type.

Table 18. Crash Summary by Median Type

Median Type	Number of Sites	Average AADT	3-Year Total Number of Crashes		
			All	*FI*	*FI Driveway-Related*
None	1	2,900	2.0	0	0
Raised, Continuous	2	28,600	35.5	12.0	4.0
Raised, Strategic	7	32,500	79.0	31.4	13.1
TWLTL	10	30,000	115.8	29.2	13.0

As shown in Table 18, sites with TWLTL medians had a significantly higher number of total crashes than all other median types, but performed similarly to roadways with raised medians with strategic openings when considering only FI crashes. Roadways with continuous raised medians had significantly fewer crashes, and the one site with no median had the fewest crashes of all median types. However, it should be noted that this trend is likely more attributed to the exposure level (very low traffic volume) than the median type.

In order to take into account traffic volumes and roadway segment lengths, the author also investigated the safety performance trends using crash rates. Figure 15 presents the relationship between FI driveway-related crash rate and access density for the 20 study roadway segments.

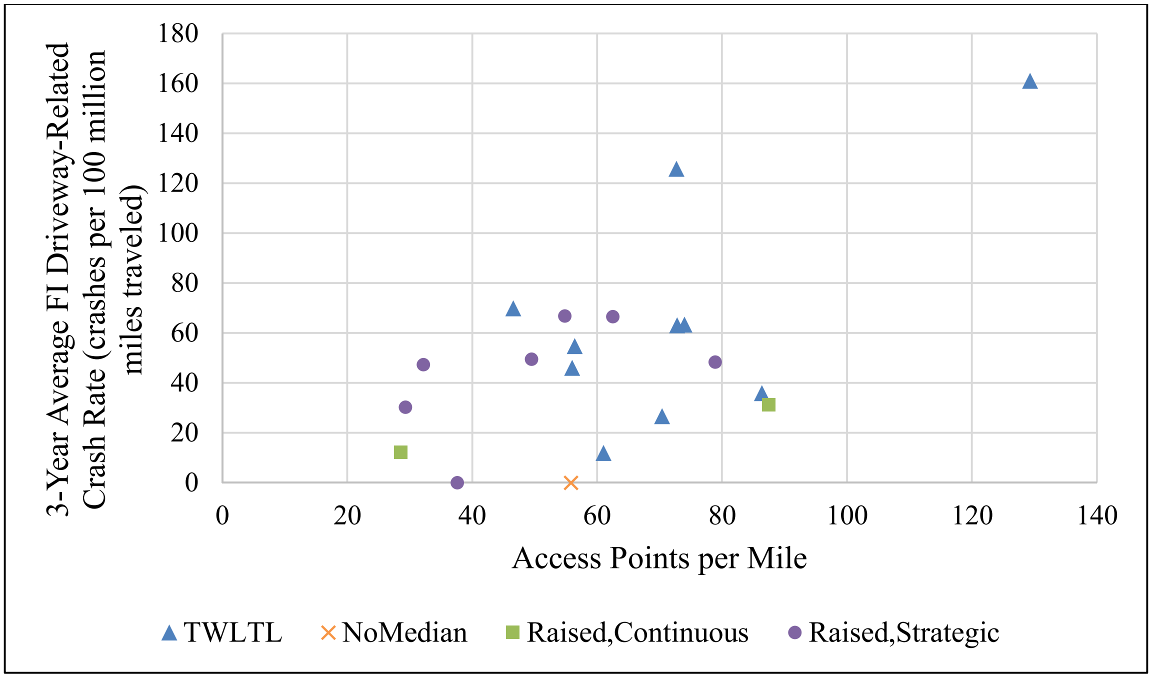


Figure 15. FI Driveway Related Crash Rates by Access Density

As shown on Figure 15, corridors with TWLTL medians had some of the highest crash rates, followed by raised medians with strategic openings, and continuous raised medians. The single corridor that had no median also happened to have zero fatal or injury crashes, and thus is shown to have the lowest crash rate. With a larger sample size, it is likely that undivided corridors would have crash rates similar to or higher than those for TWLTL corridors.

Key Findings of Safety Investigation

Table 19 and Table 20 present the total, FI, and driveway-related crash rates for the 20 roadway segments, summarized by median type and access density, respectively.

The values shown are based on the average number of crashes over the most recent three years for which data was available (2011-2013).

Table 19. Crash Rate Summary by Median Type

Median Type	Number of Sites	3-Year Average Crash Rate (crashes per 100 million miles traveled)			
		Total	*Total Driveway-Related*	*FI*	*FI Driveway-Related*
None	1	98.4	98.4	0.0	0.0
Raised, Continuous	2	79.5	24.8	35.6	21.7
Raised, Strategic	7	260.9	97.6	143.9	44.1
TWLTL	10	459.4	199.3	160.5	65.8

As shown in Table 19, crash rates were highest on roadway segments with a TWLTL, and segments with a raised median with strategic openings had higher crash rates and those with a continuous raised median. This trend can be seen across all categories of crashes, although the magnitude of the differences increases significantly when considering total crashes as opposed to driveway-related and FI crashes. Because there was only one roadway segment with no median, including it in comparisons of median type is not appropriate.

Table 20. Crash Rate Summary by Access Density

Access Points per Mile	Number of Sites	3-Year Average Crash Rate (crashes per 100 million miles traveled)			
		Total	*Total Driveway-Related*	*FI*	*FI Driveway-Related*
20-40	4	257.6	69.9	126.8	22.4
41-60	6	315.1	149.0	104.4	47.8
61-80	7	383.0	148.8	157.7	58.0
81+	3	358.4	202.9	148.5	76.0

As expected, the crash rates generally increased as access density increased (Table 20). This trend becomes clearer when PDO and non-driveway crashes are excluded. When considering all segment crashes, it appears that segments with 61-80 access points per mile have a higher crash rate than segments with more than 80 access points per mile. This unexpected trend is likely related to the single roadway segment in the 61-80 access point category which had a very short length (0.08 miles). Due to the way crash rates are calculated, very short segment lengths can inflate crash rate estimates. For the segment in question, the total crash rate was over 900.

<u>Safety Performance Trends from Literature</u>

Because rigorous statistical analyses were not feasible for the relatively small amount of available historical crash information, the development of the safety portion of the AMAT had to rely more heavily on previously established relationships from the literature. The following list summarizes the relevant findings relating to access density and median type, which are also discussed in Chapter II and presented in Appendix A.

- Every additional driveway above 10 driveways per mile increases crash risk by approximately four-percent.
- Crash risk on roadways with TWLTLs is between 10- and 35-percent less than on undivided roadways.
- Crash risk on roadways with raised medians is between 15- and 57-percent less than on roadways with TWLTLs.
- Crash risk on roadways with raised medians is up to 55-percent less than on undivided roadways.
- Note: The author assumes that the term "raised median" in the literature refers to a raised median with strategic openings.

In addition to infrastructure considerations, two previous research efforts identified land use as a strong predictor of segment-intersection and total segment crashes. The author used the regression results included in the more recent publication (Dixon, et al., 2012) to extrapolate a relationship between land use and safety performance. On urban roadway segments, the number of crashes is estimated to increase by approximately 17-percent for every 10-percent increase in the proportion of commercial and industrial driveways, after accounting for traffic volume, segment length, speed limit, median type, and number of lanes. In rural areas, the increase in crashes is slightly lower at approximately 12-percent for every 10-percent increase in the proportion of commercial and industrial driveways. In addition to the variables listed for the urban roadways, the rural model also accounted for the relative location (clustering) of driveways.

CHAPTER VII

DEVELOPMENT OF ACCESS MANAGEMENT ASSESSMENT TOOL

The assessment methodology incorporates considerations of operations, safety, and access into an objective and data-driven tool, the AMAT, for evaluating access management along a corridor. Multiple data sources provided information for the development of this tool, including the safety and operations analyses in this dissertation, findings of previous research efforts, anecdotal evidence, and engineering judgment. The final product of the AMAT is the AMR, or Access Management Rating, which is a numerical value on a scale of zero to five (where five is excellent). The AMAT procedure and accompanying AMR calculation take into account four categories of access management impacts: operations, safety, land use accessibility, and pedestrian, bicycle, and transit accessibility. Using the analysis results discussed in the previous chapter as well as research findings in the literature, the author developed a series of simple equations and lookup tables that convert user-provided information (such as roadway volume, median type, and access density, for example) to category-specific rating values. The final AMR is determined using a weighted average of these categorical rating values, which are also on a zero to five scale.

The end product of this dissertation is a proposed procedure for comprehensively evaluating access management, which the author feels is a significant contribution to the transportation industry. It should be noted, however, that the data and resources available at the time of this research did not allow for each component of the AMAT to be developed to its fullest extent. The author considers the operations component to be complete and in its final form. The safety component, which is based primarily on findings in the literature, is a solid foundation that can be built upon once further research is conducted. The accessibility component is a very basic framework that identifies the key factors that should be considered, but will require an extensive amount of research before it can be fully developed. The following sections describe the development of the equations and lookup tables that make up the AMAT procedure.

Development of Operations Equations

The AMAT procedure includes a single operations rating that accounts for traffic volume, signal spacing, median type, and access density. The development of this operations rating was based primarily on the results of the regression analysis described in Chapter VI, but also includes adjustments based on findings in the literature.

The author used the best-fit operations model (Equation 3), as the basis for the equation used to develop the operations rating (OR). Although the microsimulation and regression results did not identify access density or spacing as a significant factor in predicting average corridor speed, there are multiple studies in the literature showing such a relationship does exist (Williams, et al., 2014; TRB, 2010; McShane, et al., 1996). As discussed in Chapter II, these studies found very similar trends which indicate every 10 additional access points per mile results in a corridor speed reduction of approximately 2.5 mph. The author used this relationship to adjust the regression results (Equation 3) such that the final OR equation also accounts for access density. In addition, the author wanted to account for the relative strength of the data used to develop the equation since she had full control of (and thus has high confidence in) the analysis results from this dissertation, but had no involvement in the research discussed in the literature. To accomplish this, the author used a weighted average of the predicted speeds calculated with and without the access density adjustment, as shown in Equation 4.

Equation 4. General Form of Operations Rating (OR) Calculation

$$OR = f(0.6\ (PredSpeed) + 0.4\ (AdjPredSpeed))$$

where

OR	=	*Operations Rating, a function of Predicted Speed*
PredSpeed	=	*Predicted Speed (in mph) using Equation 3*
AdjPredSpeed	=	*Predicted Speed (in mph) using Equation 3 minus 2.5 mph per 10 access points per mile*

The final step in developing the OR equation was to apply an adjustment factor that would limit the OR result to a value between zero and five. The adjustment factor ensures that the upper and lower limits of the predicted speed values (using the minimum and maximum values for each variable) produce rating values of five and zero, respectively. The minimum and maximum values allowed for each variable (shown in Table 21) are determined by the extreme values of the data set used to develop the regression equation, or by the relevant information in the literature.

Table 21. Minimum and Maximum Variable Values for OR Calculation

Variable	Minimum Value	Maximum Value
Dsignal (feet)	400	5,280
vphpl	150	1,000
AccessDensity (access points per mile)	0	70

The resulting equation for calculating the operations factor (OF) is shown in Equation 5

Equation 5. Operations Rating (OR) Calculation

$$OR = 5 - \frac{8.31 - (0.002Dsignal - MedTyp - 0.015vphpl - \frac{AccDen}{10})}{6.73}$$

where

OR	=	*Operations Rating*
MedTyp	=	*Variable for Median Type, Determined using* Table 22
Dsignal	=	*Distance between Signalized Intersections in feet*
Vphpl	=	*Volume per Hour per Lane*
AccDen	=	*Access Points per Mile*

Table 22 presents the possible values for the variable "MedTyp", which are the coefficient estimates for each median type from Equation 3.

Table 22. Lookup Table for Median Type Value in OR Calculation

Median Type	Value
Continuous	0.00
TWLTL	2.77
Strategic	4.14

Development of Safety Equations

The AMAT procedure includes a single safety rating (SR) that accounts for median type, access density, and land use. Because the safety analyses were severely limited by the amount of crash data available, the development of the safety lookup tables relied heavily on findings from the literature.

Previous research suggests that, on average, crash risk on roadways with a TWLTL is 30-percent higher than on roadways with a raised median and 20-percent lower than on undivided roadways. The literature often refers only to raised medians and does not differentiate between continuous raised medians and raised medians with strategic openings. Because raised medians with strategic openings are much more common than continuous raised medians, the author assumes that the term "raised median" in the literature refers to the former. The limited safety investigation conducted as part of this dissertation (see Chapter VI) suggests that a continuous raised median has at least a 50-percent lower crash risk than a raised median with strategic openings. However, given the relative safety performance of other median types in the literature, this seems excessively high. Considering a raised median with strategic openings is associated with a 30-percent decrease in crash risk compared to a TWLTL, the author conservatively estimates that a continuous raised median correlates to a 20-percent lower crash risk than a raised median with strategic openings. With regards to access density, many publications suggest a four-percent increase in crash risk for every additional driveway above 10 driveways per mile. Finally, previous research has shown a link between safety performance and land use. A study by Dixon, et al. (2012) suggests that the number of segment crashes on urban roadways increases by 17-percent for every 10-percent increase in the proportion of commercial and industrial driveways.

The author used estimated crash rates as the measure of safety performance for developing the SR calculation equation. Using an arbitrarily selected base condition of 10 crashes per 100 million vehicle miles traveled, the author developed an equation to account for the relationships found in the literature. Each additional access point per mile (above 10) increases the crash rate by 4-percent. Relative to a raised median with strategic openings, the crash rates are 20-percent lower for a continuous raised median, 30-percent higher for a TWLTL median, and 50-percent higher for no median. Finally, the crash rate increases by 17-percent for every 10-percent increase in the proportion of commercial and industrial driveways.

While the final SR calculation accounts for all of these relationships, multiple studies identified similar relationships between safety performance, median type, and access density, while only one study quantified the impact of land use on safety performance. To account for the difference in how extensively each of the relationships has been researched, the SR equation uses a weighted average of the estimated crash rates, as shown in Equation 6.

Equation 6. General Form of Safety Rating (SR) Calculation

$$SR = f(0.6\left(CrashRate_{A,M}\right) + 0.4\left(CrashRate_{LU}\right))$$

where

SR	=	*Safety Rating, a function of Estimated Crash Rates*
$CrashRate_{AM}$	=	*Estimated Crash Rate using access density and median type relationships*
$CrashRate_{LU}$	=	*Estimated Crash Rate using land use relationship*

As with the OR calculation presented previously, the SR calculation includes an adjustment factor which ensures that the upper and lower limits of the estimated crash rate values (using the minimum and maximum values for each variable) produce ratings values of five and zero, respectively. The minimum and maximum values allowed for each variable (shown in Table 23) correspond to the extreme values presented in the literature related to each variable.

Table 23. Minimum and Maximum Variable Values for SR Calculation

Variable	**Minimum Value**	**Maximum Value**
Median	0.8	1.3
# ComIndDW/TotDW	0	1
AccessDensity (access points per mile)	10	70

The resulting equation for calculating the safety rating (SR) is shown in Equation 7.

Equation 7. Safety Rating (SR) Calculation

$$SR = \frac{\left(37.32 - 6 \times MedTyp \times \left(1 + .04(AccDen - 10)\right) - 4\left(1 + 1.7 \times \frac{\#ComIndDW}{Total\#DW}\right)\right.}{5.7}$$

where

SR	=	*Safety Rating*
$MedTyp$	=	*Variable for Median Type, Determined using Table 22*
$AccDen$	=	*Access Points per Mile*
$\#ComIndDW$	=	*Number of Commercial and Industrial Driveways*
$Total\#DW$	=	*Total Number of Driveways*

Table 24 presents the possible values for the variable "MedTyp", which are estimates from the literature findings.

Table 24. Lookup Table for Median Type Value in SR Calculation

Median Type	Value
Continuous	0.8
TWLTL	1.3
Strategic	1.0

Development of Accessibility Lookup Tables

The AMAT procedure includes two accessibility ratings, AR_1 and AR_2. The first accessibility rating variable, AR_1, takes into account the land use impacts of access management while AR_2 takes into consideration the accessibility impacts for pedestrians, bicyclists, and transit users. Because very little published information exists regarding access management and accessibility, the lookup tables described in this section are primarily based on general guidelines in the literature and the author's engineering judgment. As such, the accessibility component of the AMAT should only be considered as a proposed framework for taking into account the access management impacts related to bicyclists, pedestrians, transit users, and adjacent land uses. Additional research is required before the accessibility component can be considered complete.

Accessibility Rating 1 (AR_1)

The variable AR_1 accounts for the impacts of a secondary street network and median type (a surrogate for driveway restrictions) on adjacent developments. The survey of practitioners presented in Chapter IV revealed that the presence or lack of a secondary street network (which provides side-street access to developments) and inter-parcel connections are common considerations in evaluating access management along a corridor.

The economics based literature described in Chapter II indicates that access management projects, including median installations and driveway restrictions, have little to no negative impact on the property value or vitality of adjacent businesses. Additionally, a previous study of driveway restriction impacts on corner lot developments suggests that when a minor roadway access is present, providing unrestricted access to the major roadway does not reduce the amount of travel time required to enter and exit the development, particularly at higher roadway volumes (Brown and Dixon, 2015). However, it is reasonable to assume that restricting the sole access point to a development will have a tangible impact on the travel patterns of development owners and patrons, even if that impact does not result in decreased business vitality. The author felt it important to account for the access considerations described above, and did so through the AR_1 variable. Because no quantitative data is available to estimate the precise accessibility impacts, the author subjectively assigned the ratings using engineering judgment. The complete lookup table for AR_1 is presented in Table 25.

Table 25. Lookup Table for Accessibility Rating 1 (AR_1): Traffic Volume, Median Type, and Land Use

Median Type	Proportion of Developments with Access to a Minor Roadway	Hourly Traffic Volume per Lane (vphpl)			
		< 600	***601-800***	***800-1000***	***> 1000***
None	≤ 50 %	2	1	0	0
	> 50 %	3	2	1	0
TWLTL	≤ 50 %	3	2	1	0
	> 50 %	3	3	2	1
Raised with Strategic Openings	≤ 50 %	4	3	3	2
	> 50 %	4	4	4	3
Continuous Raised	≤ 50 %	4	4	4	4
	> 50 %	5	5	5	5

As shown in Table 25, a more extensive secondary network is associated with a higher rating since driveway restrictions and congestion levels will have a lesser impact on patrons needing to access adjacent developments due to the presence of alternative routes. Additionally, previous research has suggested that depending on volume levels, unrestricted access is not necessarily beneficial to adjacent businesses even though business owners may claim otherwise. As such, the author selected the ratings in Table 25 to represent the trends more commonly associated with good access management practices (e.g., divided roadways are preferable to undivided roadways).

Accessibility Rating 2 (AR_2)

The second accessibility rating (AR_2) is the sum of three factors that account for pedestrian facilities (f_p), bicycle facilities (f_b), and transit facilities (f_t). If a roadway has the "best case" conditions for all three factors, the combined accessibility rating (AR_2) will be five. Because there are significantly more pedestrians than bicyclists or transit riders, particularly in the U.S., the author assigned a maximum value of three to f_p, and a maximum value of one to both f_b and f_t. Similar to the development of AR_1, the ratings for f_p, f_b, f_t, and AR_2 are primarily based on the author's engineering judgment due to a lack of available data. The process for calculating AR_2 is summarized in Equation 8.

Equation 8. Accessibility Rating 2 (AR_2) Calculation

$$AR_2 = f_p + f_b + f_t$$

where

AR_2	=	Accessibility Rating 2
f_p	=	Pedestrian Facility Factor
f_b	=	Bicycle Facility Factor
f_t	=	Transit Facility Factor

The TRB *Access Management Manual* (Williams, et al., 2014) recommends limiting the number of driveways in order to reduce the number of vehicle-pedestrian conflicts and providing continuous pedestrian facilities where pedestrian traffic is expected. Also, the 2010 HCM pedestrian LOS procedure penalizes the pedestrian score when midblock crossings are increasingly difficult (higher number of lanes) and when significant out of direction travel is required (dedicated crossing locations are far apart). The author reviewed pedestrian planning guidelines from Oregon, Washington, and Florida, but could not find any recommendations for minimum crosswalk spacing. To maintain consistency with the *Access Management Manual*'s minimum signal spacing recommendation of one-quarter mile, the author used four signalized crosswalks per mile as the threshold between categories. For urban roadways, the lookup table accounts for the presence of continuous sidewalks, the density of signalized crosswalks, and access density (see Table 26).

Table 26. Lookup Table for Pedestrian Facility Factor (f_p)

Percent of Corridor with Continuous Sidewalks	**Signalized Crosswalks per Mile**	**Access Density (access points per mile)**			
		< 10	***10-24***	***25-40***	***> 40***
> 75%	≥ 4	3	2	1	1
	< 4	2	1	1	0.5
50-75%	≥ 4	2	1	0.5	0.5
	< 4	1	0.5	0.5	0
< 50%	≥ 4	1	0.5	0	0
	< 4	0.5	0	0	0

The bicycle facilities factor, f_b, takes into account the type of bicycle facilities present and the roadway speed. The TRB *Access Management Manual* (Williams, et al., 2014) recommends providing dedicated bicycle facilities in urban areas, but suggests that wide, high-quality paved shoulders can be used in rural areas. Additionally, the Manual on Uniform Traffic Control Devices (FHWA, 2009) states that shared lanes (marked with a sharrow) should not be used on roadways with a speed limit above 35 mph. The bicycle facilities factor lookup table is presented in Table 27.

Table 27. Lookup Table for Bicycle Facility Factor (f_b)

Bicycle Facilities Present	**Roadway Speed**	
	≤ 35 mph	***> 35 mph***
None	0	0
Wide Paved Shoulder	0.5	0.5
Shared Lane (Marked)	0.5	0
On-Street Bicycle Lane	1.0	1.0
Off-Street Bicycle or Shared Use Path	1.0	1.0

The final variable in the calculation of the second accessibility rating and the overall AMR is the transit facilities factor, f_t. The TRB *Access Management Manual* (Williams, et al., 2014) provides recommendations for the density of transit stops in urban and suburban areas, and suggests that transit stops in rural areas can be placed as needed. The author used this information to develop the transit facilities factor lookup table, presented in Table 28.

Table 28. Lookup Table for Transit Facility Factor (f_t)

Number of Transit Stops per Mile	f_t
0	0
1-5	0.5
> 5	1.0

AMR Calculation

The final component of the AMAT is the calculation of the AMR, which utilizes the above lookup tables and equations to yield a single value which represents the level of access management along a corridor. The AMR is an integer value on a scale of zero to five, with zero representing poor access management and five representing excellent access management. Equation 9 presents the simple process for calculating the AMR from the operations, safety, and accessibility considerations described in this chapter.

Equation 9. AMR Calculation

$$AMR = A_1(OR) + A_2(SR) + A_3(AR_1) + A_4(AR_2)$$

where

AMR	=	Access Management Rating, rounded to the nearest whole number
A_1, A_2, A_3, A_4	=	Adjustment Factors
OR	=	Operations Rating
SR	=	Safety Rating
AR_1, AR_2	=	Accessibility and Land Use Ratings

Note: The weights applied to the operations and safety ratings represent the relative strength of the data used to develop the ratings.

The adjustment factors shown in Equation 9 provide a means to calculate a weighted average of the operations, safety, and accessibility considerations included in the AMAT. Table 29 presents the recommended values for adjustment factors A_1, A_2, A_3, and A_4, which should always sum to a value of 1.0.

Table 29. Lookup Table for Adjustment Factors (A1, A2, A3, A4)

Roadway Type	**Future Development Plan**	**A_1 (Ops.)**	**A_2 (Safety)**	**A_3 (Land Use)**	**A_4 (Bike, Ped, & Transit)**
New Construction (Undeveloped)	Low-Medium Density Land Use	0.40	0.40	0.10	0.10
	Medium-High Density Land Use	0.40	0.40	0.05	0.15
Existing (Full or Partial Development)	Low-Medium Density Land Use	0.35	0.35	0.15	0.15
	Medium-High Density Land Use	0.35	0.35	0.10	0.20

The recommended values shown in Table 29 represent the relative importance of operations, safety, land use accessibility, and bicycle, pedestrian, and transit accessibility, respectively, for different levels of existing and future development. In all cases, operations and safety (A_1 and A_2) are equally weighted. Considerations for accessibility (A_3 and A_4) have higher weights for locations where existing development is present, as land use owners and patrons will be directly impacted by access management decisions. Additionally, as the level of future planned development increases, the relative consideration of land use accessibility (A_3) decreases (in order to accommodate high levels of development, roadway safety and mobility must be a priority) while the relative consideration of bicycle, pedestrian, and transit accessibility (A_4) increases (to promote the safety and mobility of non-vehicular traffic). It should be noted that these are recommended values and the author fully expects agencies and other users to adjust these values to better represent their unique priorities and the perceived relative importance of operations, safety, and accessibility.

Summary of AMAT Development

The author used a combination of operational analyses, safety investigations, and documented findings in the literature to develop a tool for evaluating the level of access management along a corridor. The evaluation tool, called the AMAT, utilizes a series of lookup tables and equations (as presented in this chapter) to determine the access management impacts of four separate components: operations, safety, land use accessibility, and pedestrian, bicycle, and transit accessibility. The AMAT combines these factors using a simple equation that provides a comprehensive access management rating, or AMR. The following chapter (Chapter VIII) summarizes the complete AMAT procedure, guidelines for adjusting the AMAT, and an evaluation of the AMAT. Example problems utilizing the AMAT for both network screening and alternative design selection are also included in Chapter VIII.

CHAPTER VIII

THE AMAT PROCEDURE, EVALUATION, AND EXAMPLE PROBLEMS

As described in Chapter VII, the author developed the AMAT using a combination of operational analyses, safety investigations, and findings from documented research efforts. The AMAT considers four distinct categories of access management impacts: operations, safety, land use accessibility, and pedestrian, bicycle, and transit accessibility. The final result of the AMAT procedure is an access management rating, or AMR, on a scale of zero to five. The AMR represents the level of access management along the corridor, with zero being no or poor access management, while five represents excellent access management. An overview of the complete AMAT procedure, which can be broken down into six simple steps, is presented graphically as a flow chart on Figure 16. The input data variables needed to complete each step are also summarized on the figure. The accompanying lookup tables and equations needed to use the AMAT, which are noted on Figure 16, were presented in Chapter VII.

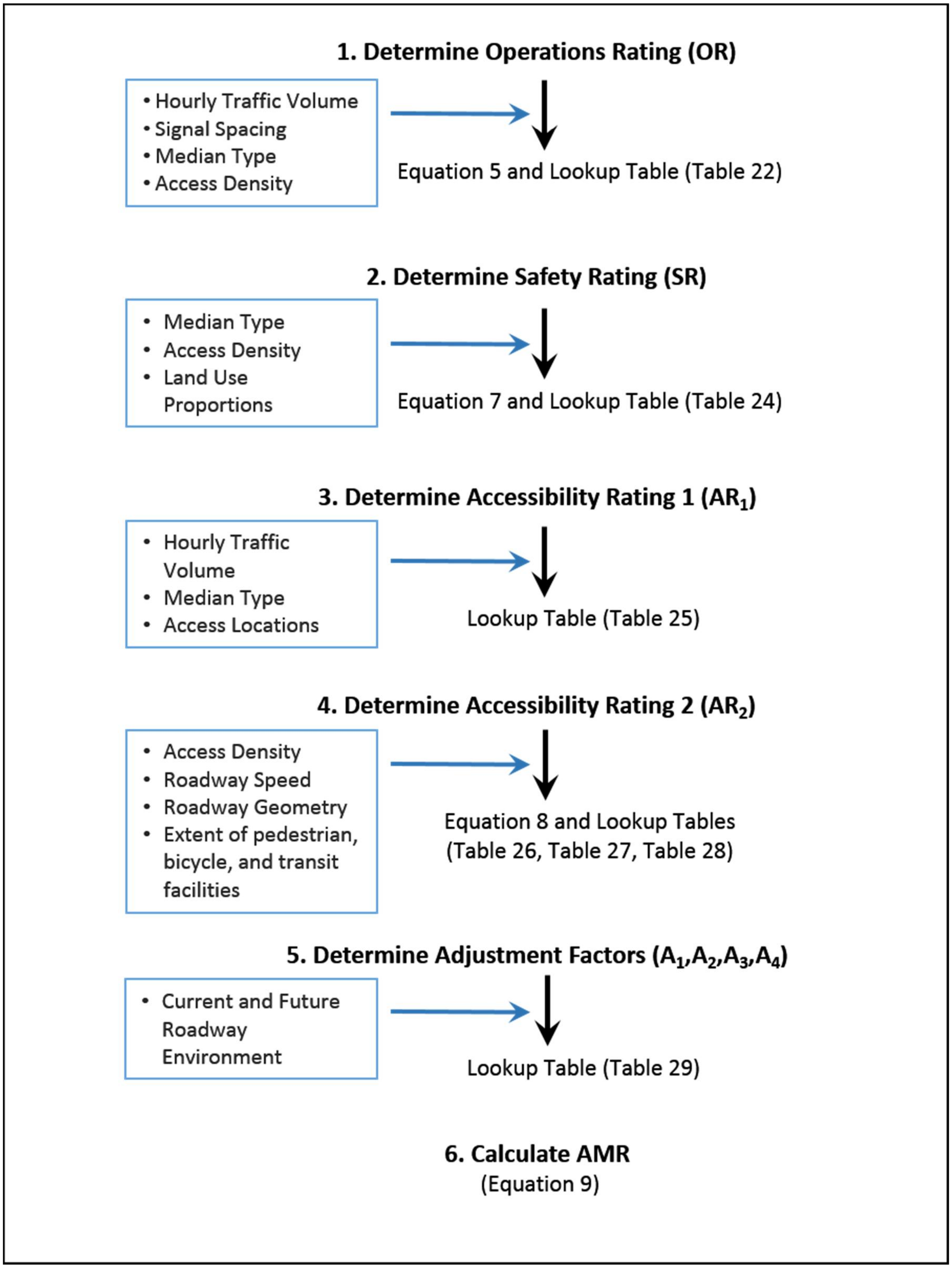


Figure 16. Overview of AMR Calculation Procedure

Guidelines for Adjusting the AMAT

The author developed the AMAT with enough flexibility that it can easily be adjusted, either to account for new research findings or to better fit an agency's needs. If the results of new research efforts suggest different relationships between access management strategies and safety, operations, or accessibility considerations, the corresponding lookup tables can be refined. The adjustments can be made manually (e.g., changing the maximum rating for a median category from 5 to 4, and adjusting all other values accordingly), or by using the new relationships the re-create performance tables and following the process outlined in this dissertation to convert the estimated performance measure values to ratings. The author anticipates that the most common refinement to the tool will be made by changing the adjustment factors in the AMR calculation. Currently, the adjustment factors give equal weight to safety and operations, and significantly lower weights to accessibility considerations. One agency might determine that a higher weight should be applied to safety performance, while a city with a high percentage of pedestrians, bicyclists, and transit users might decide that applying equal weights to safety, operations, and accessibility is more appropriate. While the author encourages agencies to refine the tool to better suit their needs, all adjustments should be made using justifiable and sound reasoning, ideally based on quantifiable data.

Evaluation of the AMAT

The survey conducted as part of the state of practice investigation (Chapter IV) provided insight into how transportation professionals currently evaluate access management along a corridor. Using aerial photography, street-view photography, and basic information about six example roadway segments, each survey participant rated the level of access management on a scale of one to five. Although the survey was based on subjective assessments and the AMAT procedure is quantitative, the author felt it important to understand the differences in corridor ratings as a means of evaluating the AMAT procedure. Table 30 compares the participant-selected ratings from the survey and the calculated AMR ratings for the four urban example corridors (the author excluded the two rural corridors from the comparison since the AMAT procedure is only applicable to urban roadways).

Table 30. Comparison of Survey Results and AMAT Urban Corridor Ratings

	Percent of Respondents that Selected Each Rating (%)					Average Survey Rating	Survey Rating Std. Dev.	Calculated AMR
	1	*2*	*3*	*4*	*5*			
Corridor 1	5	15	31	39	10	3.3	1.01	2
Corridor 3	0	3	19	49	29	4.0	0.78	4
Corridor 5	10	25	46	19	0	2.7	0.88	2
Corridor 6	17	54	20	5	3	2.2	0.85	2

The same information shown in Table 30 is also presented graphically on Figure 17. The dots indicate the average survey rating, the hash marks indicate the calculated AMR rating, and the boxes represent one standard deviation of the survey data.

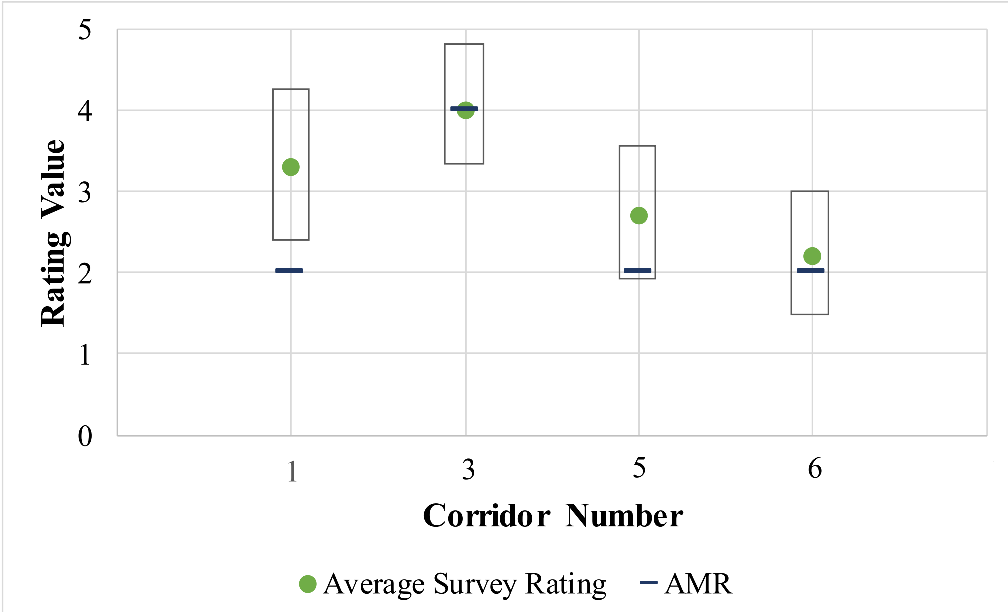


Figure 17. Comparison of Survey Results and AMAT Urban Corridor Ratings

The comparisons in Table 30 and on Figure 17 show that for Corridors 3 and 6, the AMAT generated a rating very similar to the average survey rating. The biggest discrepancy between the quantitative (AMR) and subjective (survey) ratings can be seen on Corridor 1, while Corridors 5 showed a slightly smaller difference in ratings. Even so, all of the AMR values fall within 1.3 standard deviations of the average survey rating, suggesting that the differences are not significant at a 95-percent confidence level (+/- 1.96 standard deviations). Interestingly, the magnitude of the differences between the survey ratings and AMR ratings also appear to be correlated with the standard deviation of the survey ratings. Corridors 3 and 6 had the lowest standard deviation and the most similar rating results, while Corridors 1 and 5 had the highest standard deviations and the largest rating differences. In other words, the two ratings are most similar for corridors with the highest level of agreement between subjective assessments. This suggests that the AMAT is accurately capturing the access management factors that are most commonly deemed important in the evaluation process.

While the differences may not be statistically significant, it is important to understand the likely sources of the rating discrepancies. Corridor 1 had a relatively high access density (50 access points per mile) and 100-percent commercial land use, which resulted in low safety ratings and significantly reduced the overall AMR score. According to the AMAT procedure, Corridor 5 had the lowest operations ratings of the six corridors due to high traffic volume and a TWLTL median. For both cases, the discrepancy between the subjective and quantitative ratings is likely due to one or both of the following possibilities. First, the survey respondents may have estimated the safety and operational impacts of the given roadway characteristics to be much less significant than what the literature suggests. Second, the survey respondents may have given significantly more or less weight to the various performance measures in their decision making than what is assumed in the AMAT. In either case, the author fully expected there to be inconsistencies in the ratings and attributes them to the innate and significant differences between subjective and quantitative methods. The author is confident in the data and methods used to develop the AMAT and does not feel that the above discrepancies warrant adjustments to the evaluation procedure.

AMAT Example Problems

The following example problems present two different approaches for using the AMAT in practice, one for network screening and one for alternative design selection.

Example 1: Network Screening

You are transportation planner at a state agency and are tasked with identifying roadway segments in the local jurisdiction that should be considered for access management improvement projects. The agency has selected an AMR of four or higher as being an acceptable level of access management. Use the AMAT procedure to determine if the following corridor warrants consideration for an improvement project.

Table 31. Corridor Information for Example Problem 1

Variable	Corridor Data
Roadway Type	Urban Major Arterial
Corridor Length	1.5 miles
Peak Hour Roadway Volume	3,500 vph
Number of Lanes	6
Median Type	Raised with Strategic Openings
Posted Speed Limit	45 mph
Number of Signalized Intersections	4
Number of Access Points	53
Land Use Types	60% Commercial, 20% Vacant, 20% Residential
Percent of Corridor with Continuous Sidewalks	100%
Number of Marked Crosswalks	10
Number of Signalized Crosswalks	8
Bicycle Facilities	None
Number of Transit Stops	2
Percent of Developments with Access to a Minor Roadway	40%

Step 1. Determine Operations Rating OR

The equation for OR (Equation 5) requires hourly traffic volume per lane, signal spacing, median type, and access density. .

$$Traffic\ Volume\ per\ Lane = \frac{3{,}500\ vph}{6\ lanes} = 583.3\ vphpl$$

$$Average\ Signal\ Spacing = \frac{1.5\ miles}{4\ signals} = 0.375\ miles\ (1{,}980\ ft.)$$

$$Access\ Density = \frac{53\ access\ points}{1.5\ miles} = 35.3\ access\ points\ per\ mile$$

Using Lookup Table 22, the median type value for a raised median with strategic openings is 4.14.

Using Equation 5,

$$OR = 5 - \frac{8.31 - (0.002(1980) - (4.14) - 0.015(583.3) - \frac{35.3}{10})}{6.73}$$

$$\boxed{\textbf{OR = 2.8}}$$

Step 2. Determine Safety Rating (SR)

The equation for calculating SR (Equation 7) requires access density, median type, and the number of commercial, industrial, and total driveways. From the given information, 60-percent of the driveways serve commercial or industrial land uses.

Using Lookup Table 24, the median type value for a raised median with strategic openings is 1.0.

Using Equation 7,

$$SR = \frac{(37.32 - 6 \times (1.0) \times \left(1 + .04(35.3 - 10)\right) - 4(1 + 1.7 \times (0.6))}{5.7}$$

$$\boxed{\textbf{SR = 3.0}}$$

Step 3. Determine accessibility rating AR_1

The lookup table for AR_1 (Table 25) requires hourly traffic volume, median type, and the percentage of developments with minor road access. From Step 1, the hourly traffic volume is 583.3 vphpl. From the given information, the median is a raised median with strategic openings, and 40-percent of developments have access to a minor roadway.

From Table 25, $\mathbf{AR_1 = 4}$.

Step 4. Determine accessibility rating AR_2

The variable AR_2 is the sum of three components, f_p, f_b, and f_t, which can be found in Table 26, Table 27, and Table 28, respectively. The f_p lookup table requires access density, the percentage of the corridor with continuous sidewalks, and the density of signalized crosswalks. From Step 1, the access density is 35.3 access points per mile. From the given information, 100-percent of the corridor has continuous sidewalk facilities.

$$Signalized\ Crosswalk\ Density = \frac{8\ crosswalks}{1.5\ miles} = 5.3\ crosswalks\ per\ mile$$

From Table 26, $\boldsymbol{f_p} = \mathbf{1}$.

From the given information, there are no bicycle facilities present.

From Table 27, $\boldsymbol{f_b} = \mathbf{0}$.

The lookup table for f_t (Table 28) requires the density of transit stops.

$$Transit\ Stop\ Density = \frac{2\ stops}{1.5\ miles} = 1.3\ stops\ per\ mile$$

From Table 28, $\boldsymbol{f_t} = \mathbf{0.5}$.

Using Equation 8, AR_2 is the sum of f_p, f_b, and f_t,

$$\boxed{\boldsymbol{AR_2} = 1 + 0 + 0.5 = \mathbf{1.5}}$$

Step 5. Determine adjustment factors A_1, A_2, A_3, and A_4

The lookup table for the adjustment factors (Table 29) requires information regarding the roadway type and future development plans. The given information suggests that this is an existing roadway and that has a medium-high level of development (currently, only 20-percent of the land is undeveloped).

From Table 29, $\mathbf{A_1 = 0.35}$, $\mathbf{A_2 = 0.35}$, $\mathbf{A_3 = 0.1}$, and $\mathbf{A_4 = 0.2}$.

Step 6. Calculate AMR

Using Equation 9,

$$AMR = 0.35(2.8) + 0.35(3.0) + 0.1(4) + 0.2(1.5)$$

$$\boxed{\boldsymbol{AMR} = 2.7 = \mathbf{3}}$$

Based on an AMR of 3, which is lower than your agency's threshold value of 4, you would recommend this corridor for consideration for an access management improvement project.

Example 2: Alternative Design Selection

You are an engineer at a consulting firm and have been tasked with developing a design plan for new stretch of urban arterial. The right-of-way constraints allow for a four lane divided roadway. You have developed two design alternatives – the first alternative includes a high density of driveways and a raised median with strategically placed openings, while the second alternative has a lower access density and a center two-way left-turn lane. Because the area is expected to grow rapidly in the next decade, you want to include an access management evaluation as one part of the alternative selection process. Use the AMAT procedure to determine which alternative has the best performance in terms of access management.

Table 32. Corridor Information for Example Problem 2

Variable	Corridor Data	
	Alternative 1	*Alternative 2*
Roadway Type	Urban Arterial	Urban Arterial
Corridor Length	2.0 miles	2.0 miles
Peak Hour Roadway Volume	2,600 vph	2,600 vph
Number of Lanes	4	4
Median Type	Raised, Strategic	TWLTL
Posted Speed Limit	40 mph	40 mph
Number of Signalized Intersections	6	3
Number of Access Points	60	25
Land Use Types	40% Commercial, 20% Residential, 40% Vacant	40% Commercial, 20% Residential, 40% Vacant
Percent of Corridor with Continuous Sidewalks	50%	50%
Number of Marked Crosswalks	2	1
Number of Signalized Crosswalks	4	2
Bicycle Facilities	Bike Lane	None
Number of Transit Stops	0	0
Percent of Developments with Access to a Minor Roadway	30%	30%

Step 1. Determine Operations Ratings (OR)

The equation for calculating OR (Equation 5) requires hourly traffic volume per lane, signal spacing, median type, and access density.

For Alternative 1 and 2,

$$Traffic\ Volume\ per\ Lane = \frac{2{,}600\ vph}{4\ lanes} = 650\ vphpl$$

The access density for Alternative 1 is:

$$Access\ Density = \frac{60\ access\ points}{2\ miles} = 30\ access\ points\ per\ mile$$

The access density for Alternative 2 is:

$$Access\ Density = \frac{25\ access\ points}{2\ miles} = 12.5\ access\ points\ per\ mile$$

The signal spacing for Alternative 1 is:

$$Average\ Signal\ Spacing = \frac{2\ miles}{6\ signals} = 0.333\ miles\ (1{,}760\ ft.)$$

The signal spacing for Alternative 2 is:

$$Average\ Signal\ Spacing = \frac{2\ miles}{3\ signals} = 0.667\ miles\ (3{,}520\ ft.)$$

Using Lookup Table 22, the median type value for a raised median with strategic openings (Alternative 1) is 4.14 and is 2.77 for a TWLTL (Alternative 2).

Using Equation 5,

$$OR(Alt\ 1) = 5 - \frac{8.31 - (0.002(1760) - (4.14) - 0.015(650) - \frac{30}{10})}{6.73}$$

$$OR(Alt\ 2) = 5 - \frac{8.31 - (0.002(3520) - (2.77) - 0.015(650) - \frac{12.5}{10})}{6.73}$$

OR (Alternative 1) = **1.8**
OR (Alternative 2) = **2.8**

Step 2. Determine Safety Ratings (SR)

The equation for calculating SR (Equation 7) requires access density, median type, and the number of commercial, industrial, and total driveways. From the given information, 40-percent of the driveways serve commercial or industrial land uses in both alternatives.

Using Lookup Table 24, the median type value for a raised median with strategic openings is 1.0 (Alternative 1) and is 1.3 for a TWLTL (Alternative 2).

Using Equation 7,

$$SR\ (Alt\ 1) = \frac{(37.32 - 6 \times (1.0) \times \left(1 + .04(30 - 10)\right) - 4(1 + 1.7 \times (0.4))}{5.7}$$

$$SR\ (Alt\ 2) = \frac{(37.32 - 6 \times (1.3) \times \left(1 + .04(12.5 - 10)\right) - 4(1 + 1.7 \times (0.4))}{5.7}$$

SR (Alternative 1) = **3.5**
SR (Alternative 2) = **3.9**

Step 3. Determine accessibility rating AR_1

The lookup table for AR_1 (Table 25) requires hourly traffic volume, median type, and the percentage of developments with minor road access. From Step 1, the hourly traffic volume is 650 vphpl and 30-percent of developments have access to a minor roadway for both alternatives.

From Table 25,
AR_1 (Alternative 1) = 3
AR_1 (Alternative 2) = 2

Step 4. Determine accessibility rating AR_2

The variable AR_2 is the sum of three components, f_p, f_b, and f_t, which can be found in Table 26, Table 27, and Table 28, respectively. The f_p lookup table requires access density, the percentage of the corridor with continuous sidewalks, and the density of signalized crosswalks. From Step 1, the access density for Alternative 1 and 2 is 30 and 12.5 access points per mile, respectively. Alternative 1 has four signalized intersections while Alternative 2 has two. Both alternatives have sidewalks along 50-percent of the corridor, and Alternative 1 includes bicycle lanes (Alternative 2 has no bicycle facilities).

From Table 26, $\boldsymbol{f_p}$ **= 0.5** for Alternative 1 and Alternative 2.

Alternative 1 includes a dedicated bicycle lane while Alternative 2 does not provide bicycle facilities.

From Table 27, $\boldsymbol{f_b} = \mathbf{1}$ for Alternative 1, $\boldsymbol{f_b} = \mathbf{0}$ for Alternative 2.

Neither alternative includes facilities for transit.

From Table 28, $\boldsymbol{f_t} = \mathbf{0}$ for both alternatives.

Using Equation 8, AR_2 is the sum of f_p, f_b, and f_t,

$$\boxed{\begin{array}{l} \boldsymbol{AR_2} = 0.5 + 1 + 0 = \mathbf{1.5}\ (\boldsymbol{Alternative\ 1}) \\ \boldsymbol{AR_2} = 0.5 + 0 + 0 = \mathbf{0.5}\ (\boldsymbol{Alternative\ 2}) \end{array}}$$

Step 5. Determine adjustment factors A_1, A_2, A_3, and A_4

The lookup table for the adjustment factors (Table 29) requires information regarding the roadway type and future development plans. The given information suggests that this is new roadway and that is expected to have a high level of development in the future. The adjustment factors are the same for both alternatives.

From Table 29, $\mathbf{A_1 = 0.4}$, $\mathbf{A_2 = 0.4}$, $\mathbf{A_3 = 0.05}$, and $\mathbf{A_4 = 0.15}$.

Step 6. Calculate AMR

Using Equation 9,

$$AMR\ (Alternative\ 1) = 0.4(1.8) + 0.4(3.5) + 0.05(3) + 0.15(1.5) = 2.48$$

$$AMR\ (Alternative\ 2) = 0.4(2.8) + 0.4(3.9) + 0.05(2) + 0.15(0.5) = 2.83$$

$$\boxed{\begin{array}{c} \boldsymbol{AMR\ \ for\ Alternative\ 1 = 2} \\ \boldsymbol{AMR\ for\ Alternative\ 2 = 3} \end{array}}$$

Based on the AMR results, Alternative 2 performs better than Alternative 1 with regards to access management.

CHAPTER IX

SUMMARY

This dissertation documents the development of a quantitative, data-driven methodology for evaluating access management on an urban corridor. The methodology, referred to as the Access Management Assessment Tool (AMAT), incorporates considerations of the operations, safety, and accessibility impacts of access management strategies. The final product of the AMAT is an Access Management Rating, or AMR. The AMR is an integer value on a scale of zero to five, with zero representing a lack of access management and five representing excellent access management.

Previous research has typically focused on isolated relationships between a single access management strategy and operations, safety, or economic impacts. While this body of research is extensive, particularly with regards to median configuration and access density, access management projects rarely implement a single strategy. Because there is no documented way to assess the comprehensive impact of implementing multiple access management strategies simultaneously, large-scale access management evaluations must be made using a certain amount of subjective assessments and engineering judgment.

After conducting a thorough review of the literature, the author conducted a survey of transportation professionals to gain insight into the current state of practice regarding access management evaluations. The survey results indicated that there was little consistency in the way practitioners evaluate access management along a corridor.

For half of the example corridors included in the survey, respondents selected all possible ratings (one through five). Interestingly, the inconsistency was still apparent among respondents with extensive access management experience. This suggests that even with an understanding of the impacts of various access management strategies, the relative importance of each impact is a subjective decision, and thus the evaluation of a corridor will vary significantly between professionals.

In order to develop a quantitative, data-driven process for evaluating access management, the author used a combination of microsimulation analyses, safety investigations, and relevant findings of previous research efforts that are documented in the literature. A field data collection effort provided roadway characteristics (number of lanes, median configuration, access configuration, etc.), operational performance data (travel time and speeds, queue lengths, and signal timing parameters), and safety performance data (historical crash records) for 16 arterial corridors in five different states. All 16 corridors were in close proximity to a grade-separated interchange. 14 of the interchanges were conventional designs (stop-controlled diamond, signalized diamond, single-point urban interchange, and partial cloverleaf) and two were alternative designs (diverging diamond interchange and roundabout terminal treatments).

The author investigated the operational impacts of various access management strategies through an extensive microsimulation effort using the simulation software package VISSIM 7.0. The author selected 10 of the 16 corridors to include in the operations and safety investigations (reserving four for use in the survey of practitioners and excluding the two alternative interchange designs). After creating and validating models of the base field conditions, the author developed alternative scenario models with varying access management characteristics. The alternative models varied according to traffic volume, median type, access density, signal density, and the distance between driveways and signalized intersections. In all, the author developed nearly 400 VISSIM models which provided over 800 operational performance data points (considering each side of the interchange as a separate corridor). A regression analysis of the VISSIM results identified median type, signal density, and traffic volume as significant predictors of average corridor speed.

Initially, the author intended to use the Surrogate Safety Assessment Model (SSAM) software package to evaluate the safety performance of the alternative scenarios using the VISSIM models as input data. Unfortunately, a preliminary attempt to validate the results of the SSAM against historical crash data for three sites showed that the software was not accurately estimating the safety performance of the corridors. The discrepancy between the estimated and actual safety performance may have been due to the unique characteristics of the interchange sites, underlying issues in the design of the VISSIM models, or an issue with the SSAM software package. Because the SSAM software could not be used, the author was limited to using historical crash data for the 10 interchange locations. Even with three years of historical data, the sample size was far too small to conduct rigorous statistical analyses of safety performance. As such, the author relied on trend analyses to investigate the safety impacts of access management characteristics. In general, corridors with continuous raised medians had the lowest crash rates, followed by raised medians with strategic openings, TWLTLs, and no median. Additionally, crash rates tended to increase as access density increased. These observations are consistent with the trends documented in the literature.

Although the published information is limited, the author felt it important to account for the accessibility impacts of access management strategies, including impacts to business owners, pedestrians, bicyclists, and transit riders. Wherever possible, the author referenced relevant literature to estimate the potential impacts to these non-automobile road users, and supplemented with engineering judgment when necessary.

The author combined the findings of the investigations into operations, safety, and accessibility impacts of access management strategies into a simple, streamlined process for evaluating access management along a corridor. The AMAT procedure involves six straightforward steps:

1. Determine Operations Impact Ratings
2. Determine Safety Impact Ratings
3. Determine Land Use Accessibility Impact Ratings
4. Determine Pedestrian, Bicycle, and Transit Accessibility Impact Ratings
5. Determine Adjustment Factors
6. Calculate AMR

Steps one through five are easily completed using equations and lookup tables, while the AMR calculation combines the previously determined ratings using the following equation.

Equation 10. AMR Calculation (repeated)

$$AMR = A_1(OR) + A_2(SR) + A_3(AR_1) + A_4(AR_2)$$

where

AMR	=	Access Management Rating, rounded to the nearest whole number
A_1, A_2, A_3, A_4	=	Adjustment Factors
OR	=	Operations Rating
SR	=	Safety Rating
AR_1, AR_2	=	Accessibility and Land Use Ratings

To use the AMAT procedure, the following corridor information must be known:

- Hourly traffic volume
- Number of lanes
- Median type
- Access density
- Signal spacing or density
- Roadway speed
- Proportion of land use types
- Number of developments with access to a minor roadway
- Pedestrian facilities (sidewalks and crosswalks)
- Bicycle facilities
- Transit stop density
- The existing and future (planned) development density

Contributions of this Research

The review of literature highlighted the lack of information available for estimating the safety, operational, and land use impacts of implementing multiple access management strategies simultaneously. As a result, practitioners must impart subjective assessments and engineering judgment when making access management decisions, which was apparent from the results of the state of practice survey. There is a clear need for a consistent, objective, and quantifiable means of evaluating access management impacts and performance on a large scale.

The AMAT procedure is a practice-ready tool that can be easily implemented to quantitatively evaluate access management along a corridor. The resulting AMR value allows for straightforward comparisons between corridors, or between design alternatives for the same corridor. The author envisions this tool being utilized by state and local agencies for network screening purposes as it can easily identify corridors that do not meet a standard AMR threshold value (which can be set by each agency), and thus may warrant consideration for improvement. Additionally, design engineers and access management professionals can use the AMAT to compare the access management performance of different design alternatives for a new corridor or the reconstruction of an existing corridor. Use of the AMAT will improve the consistency in which access management decisions are made within the transportation profession. Furthermore, funds allocated to access management projects will be used more efficiently as the corridors most needing improvement will be accurately identified.

Limitations of the AMAT

The author developed the AMAT with enough flexibility that it can be applied to any corridor. However, the data used to develop the AMAT was limited to major arterials in close proximity to a grade-separated interchange. While the data set initially included both urban and rural corridors, the rural data was very limited and thus was excluded from the data set; As a result, the final AMAT procedure is applicable only to urban corridors. Lastly, the accessibility considerations in the AMAT are heavily dependent on engineering judgment due to a lack of available information, and thus may not accurately represent the true access management impacts relating to land use, pedestrians, bicyclists, and transit riders.

Recommendations for Future Work

The AMAT was developed using data from 16 major arterial crossroads in the vicinity of interchanges. The author believes that the AMAT is applicable to similar corridors that are not in the vicinity of interchanges, however conducting additional operational and safety analyses on a larger data set of roadway environments and functional classifications would significantly enhance the methodology.

Expanding the data set to include rural considerations would significantly broaden the applicability of the tool. Furthermore, the unique access management considerations in urban and rural areas may be better suited by the development of two separate but complimentary AMAT procedures.

The regression analysis of the operational impacts suggested that volume-per-lane was a better predictor of corridor speed than total roadway volume and number of lanes as separate variables. As such, the AMAT uses vphpl instead of vph and number of lanes. However, this strategy fails to account for the different functionality of two-lane roads versus multi-lane roads. It is likely that interactions between through traffic and driveway-related traffic would result in different operational impacts for multi-lane roads than two-lane roads. Further research on these potential differences would provide valuable insights for future refinement of the AMAT.

The author thoroughly investigated the operational impacts of access management strategies on the study corridors, however the safety investigation was limited by the relatively small amount of available data. As such, the accuracy of the methodology would be improved by further research on the comprehensive safety impacts of implementing multiple access management strategies.

Similarly, the author relied on a very limited body of research and a relatively large amount of engineering judgment in estimating the land use, pedestrian, bicycle, and transit impacts of access management strategies. Any additional research on these topics would significantly improve the strength of the AMAT methodology.

Lastly, the AMAT procedure could be further enhanced by incorporating economic considerations such as the costs associated with construction, financial impacts to businesses, and societal impacts of safety and operational performance.

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APPENDIX A: SUMMARY OF LITERATURE RELATING ACCESS MANAGEMENT TO SAFETY, OPERATIONS, AND LAND USE

Table A1: Summary of Literature on Safety Impacts of Access Management

Access Management Consideration	Safety Impacts	Source
Driveway Density/Spacing	Each additional driveway per mile results in 4% increase in crash risk	Gluck, Levinson, & Stover, 1999; Papayannoulis, et al., 1999; Williams, Stover, Dixon, & Demosthenes, 2014
	On urban roads, an increase from 20-40 access points per mile results in an increase in crash rates of 2.1 on undivided roads, 2.0 for TWLTL roads, and 1.7 on raised median roads.	Gluck, Levinson, & Stover, 1999; Williams, Stover, Dixon, & Demosthenes, 2014
	In urban areas, driveway density and driveway land use were significant variables for predicting corridor crash rates. In rural areas, driveway density and driveway clustering were significant.	Dixon, Avelar, Brown, Mecham, vanSchallkwyk, 2012
Driveway Design	Increasing driveway visualization with illumination reduces crashes by up to 42%	S&K Transportation Consultants, 2000
Driveway Proximity to Intersections and Interchanges	Increasing spacing from interchange to driveway from 300 ft to 600 ft reduces crash risk by 50%	Rakha, et al., 2008
Signalized Intersection Spacing and Coordination	Increasing signal density from 2 to 4 per mile may result in crash risk increase of up to 200%, but averages closer to 40%.	Gluck, Levinson, & Stover, 1999; Williams, Stover, Dixon, & Demosthenes, 2014
Auxiliary Lanes	On 4-lane roads, adding a left-turn bay to a signalized or unsignalized intersection reduces total crashes by 25-50% and up to 75%, respecitvely. Adding a right-turn bay reduces crashes by up to 20%.	S&K Transportation Consultants, 2000

Median Configuration	Replacing a TWLTL with a raised median can reduce crash rates by 30-50%, providing a TWLTL on an otherwise undivided roadway reduces the crash rate by 10-20%	Gluck, Levinson, & Stover, 1999; Parsonsons, Waters, and Fincher, 1993
	On urban roads, an increase from 20-40 access points per mile results in an increase in crash rates of 2.1 on undivided roads, 2.0 for TWLTL roads, and 1.7 on raised median roads.	Gluck, Levinson, & Stover, 1999; Williams, Stover, Dixon, & Demosthenes, 2014
	Adding a TWLTL to an unidivided road reduces crashes by 35%	S&K Transportation Consultants, 2000
	Adding a raised median to an unidivided road reduces crashes by 55%	
	Replacing a TWLTL with a raised median reduces crashes by 15-57%	

Table A2: Summary of Literature on Operational Impacts of Access Management

Access Management Consideration	Operational Impacts	Source
Driveway Density/Spacing	Free flow speeds decrease an average of 2.5mph for every additional 10 access points per mile.	2010 HCM, Chapter 17
	Increasing driveway density from zero to 8 driveways per mile (on one side of the road) reduces travel speed in the primary direction by 5mph. Increasing to 16 dw per mile reduces primary direction speed by an additional 2 mph, and opposing direction speed by a total of 2-3mph.	McShane, et al, 1996
Driveway Design	Increasing driveway speed from 5 to 10 mph reduces through delay by 50% per maneuver	S&K Transportation Consultants, 2000
Driveway Proximity to Intersections and Interchanges	Under high development (high roadway and dw volume), decreasing spacing between interchange and first signalized intersection from 1600 ft to 300 ft reduces speed by approx. 35% of ideal speed. For low development roadways, the same change reduces speed by 25% of ideal speed.	Washburn, 2006
Signalized Intersection Spacing and Coordination	A reduction in speed of 2-3mph can be expected with every aditional traffic signal per mile. Similarly, every additional signal per mile above two increases travel time by approximately 7%	Gluck, Levinson, & Stover, 1999
	Providing long signal spacing with limited access density reduces delay by up to 59%.	S&K Transportation Consultants, 2000

Auxiliary Lanes	Adding a left-turn bay can increase capacity by up to 25%.	S&K Transportation Consultants, 2000
Median Configuration	Adding a TWLTL to an unidivided road reduces delay by 30% and increases capacity by 30%	S&K Transportation Consultants, 2000
	Adding a raised median to an unidivided road reduces delay by 30% and increases capacity by 30%	
	Roadways with raised medians and strategic openings generated similar levels of delay to through traffic as TWLTLs, while both median types resulted in much lower delays than undivided roadways.	Bonneson & McCoy, 1997

Table A3: Summary of Literature on Land Use Impacts of Access Management

Access Management Consideration	Land Use Impacts	Source
Median Configuration	Property values increased an average of 7% after raised median installations in Texas. Gas station, auto repair, and other service businesses saw a decrease in customers per day and gross sales. The construction phase had the largest economic impact on adjacent businesses.	Eisele & Frawley, 1999
	Except where significant out-of-direction is required, changes to access or travel patterns had little to no effect on the viability of adjacent land uses in a study of 15 locations in Kansas.	Rees, Orrick, & Marx, 2000
	Quality of service and quality of products were ranked much higher than property access in regards to factors affecting a customer's choice to visit a business.	Bonneson & McCoy, 1997
Overall Access Management	A recent study of three corridors in Houston, TX suggested that taxable sales increased or remained constant (relative to control sites) for businesses on corridors where access management projects had been implemented.	Benz, Norboge, Voigt, & Gage, 2015
	In Washington, researchers found a direct, but unquantified, correlation between access management techniques and business patronage	Vu, Shankar, and Chayanan, 2002

APPENDIX B: SURVEY QUESTIONS AND RELEVENT INFORMATION

E-Mail to TRB Access Management Committee Mailing List

From: Lacy Brown, P.E. OR H. Gene Hawkins, Ph.D., P.E.
To: TRB Access Management Committee Mailing List
Subject: Please Take Our Access Management Survey!

Greetings!

As part of a doctoral research project at Texas A&M University, we are conducting a survey of transportation professionals relating to access management on arterial roadways.   The results of this survey will be used to develop an objective and quantitative method for evaluating the level of access management along a corridor.

The survey consists of 17 questions and will take approximately 10-15 minutes to complete. Your answers to the survey questions will be anonymous and not used in any way to identify you. Your participation is completely voluntary and you can opt-out of the survey at any time.

The survey will be available until June 19, 2015. To participate in the survey or to learn more about the research project, please follow this link:
https://tamu.qualtrics.com/SE/?SID=SV_cTibSyU5MvLkKfb

If you have any questions regarding this survey, please contact Gene Hawkins at (979) 845-9946 or gene.hawkins@tamu.edu or Lacy Brown at (979) 845-9893 or lacysuebrown@tamu.edu.

Thank you for your participation. Please feel free to share this survey with other transportation professionals who may be interested in participating.

Sincerely,

Lacy Brown, Research Protocol Director
Graduate Research Fellow, Texas A&M University

Karen K. Dixon, Research Associate
Research Engineer, Texas A&M Transportation Institute

H. Gene Hawkins, Principal Investigator
Associate Professor, Zachry Department of Civil Engineering
Research Engineer, Texas A&M Transportation Institute

Full Survey Text and Questions

Evaluation of Access Management on Arterial Roadways Survey

Welcome to the "Evaluation of Access Management on Arterial Roadways" Survey. This survey is part of a doctoral research project at Texas A&M University which is focused on developing an objective and quantitative method for evaluating the level of access management along a corridor. The research is sponsored by the Federal Highway Administration (FHWA) under the Dwight D. Eisenhower Transportation Fellowship Program.

While you are under no obligation to participate in this survey, we would appreciate your participation and will use the survey results to validate and refine the evaluation methodology we have developed. This evaluation methodology will promote consistency in the assessment of corridors and the selection of access management projects. Your answers on the survey will be anonymous and not used in any way to identify you.

This survey should take between 10 and 15 minutes to complete, and consists of 17 questions. If you have any questions regarding this survey, please contact Lacy Brown at (979) 845-9893 or lacysuebrown@tamu.edu. Thank you for your participation.

Sincerely,
H. Gene Hawkins, Principal Investigator
Associate Professor, Zachry Department of Civil Engineering
Research Engineer, Texas A&M Transportation Institute

Karen K. Dixon, Research Associate
Research Engineer, Texas A&M Transportation Institute

Lacy S. Brown, Protocol Director
Graduate Research Fellow, Texas A&M University

Information about you will be kept confidential to the extent permitted or required by law. People who have access to your information include the Principal Investigator and research study personnel. Representatives of regulatory agencies such as the Office of Human Research Protections (OHRP) and entities such as the Texas A&M University Human Subjects Protection Program may access your records to make sure the study is being run correctly and that information is collected properly.

This research study has been reviewed by the Human Subjects' Protection Program and/or the Institutional Review Board at Texas A&M University. For research-related problems or questions regarding your rights as a research participant, you may contact these offices at (979) 458-4067 or irb@tamu.edu. IRB Reference Number 2015-0081.

Please click the button below to acknowledge the above information and begin the survey.

The following terms are used throughout the survey. Please make sure you review the provided definitions as they relate to the context of the survey.

Access Management: The 2014 TRB Access Management Manual definition: "the planning, regulation, and design of access between a roadway and land development. It encompasses a range of methods that preserve the safety and mobility of the traveling public by reducing conflicts on the roadway system and at its interface with other modes of travel."

AADT: Annual Average Daily Traffic (in vehicles per day - vpd).

Bike/Ped/Transit Facilities: This includes sidewalks, crosswalks, dedicated or shared bicycle lanes, shared use paths, transit stops, transit lanes, and traffic control devices used specifically for bicyclists, pedestrians, or transit vehicles.

Driveway Density: The number of driveways (on both sides of the road) per mile of corridor length.

Driveway Spacing: The distance between two consecutive driveways along a corridor, typically measured from edge of travel way-to-edge of travel way.

Full Movement Driveway: A driveway that allows all turning movements (left-turn in, left-turn out, right-turn in, and right-turn out) without restrictions.

Land Use: Referring to the types of development that exist adjacent to the roadway, typically categorized as commercial, industrial, residential, vacant, etc.

Restricted Movement Driveway: A driveway that restricts one or more turning movements through the use of a median, channelizing island, signing, or striping.

Signal Density: The number of signalized intersections per mile of corridor length.

Site Development: The internal site design of an individual land use parcel, including orientation of the building, parking lot, and access points, the parking layout, vehicular site circulation, and provided bicycle/pedestrian facilities.

TWLTL: Two-way left-turn lane median.

Q1. Please indicate which option best describes your current, or most recent, place of employment.

- ❍ City or County Government
- ❍ State or Federal Government
- ❍ Metropolitan Planning Organization
- ❍ University or College
- ❍ Private Consultant
- ❍ Advocacy Group
- ❍ Other (please specify): ____________________

Q2. Please identify your area of practice within the transportation profession (select all that apply).

- ❑ General Engineering
- ❑ Highway Design
- ❑ Planning & Policy
- ❑ Traffic Operations
- ❑ Transportation Safety
- ❑ Other (please specify): ____________________

Q3. Please indicate your experience with the concepts and principles of access management.

- ❍ I am unfamiliar with the topic of access management.
- ❍ I have a working knowledge of access management.
- ❍ I work on access management projects regularly.
- ❍ I am an access management expert.

Q4. Are you a licensed professional engineer or your country's equivalent?

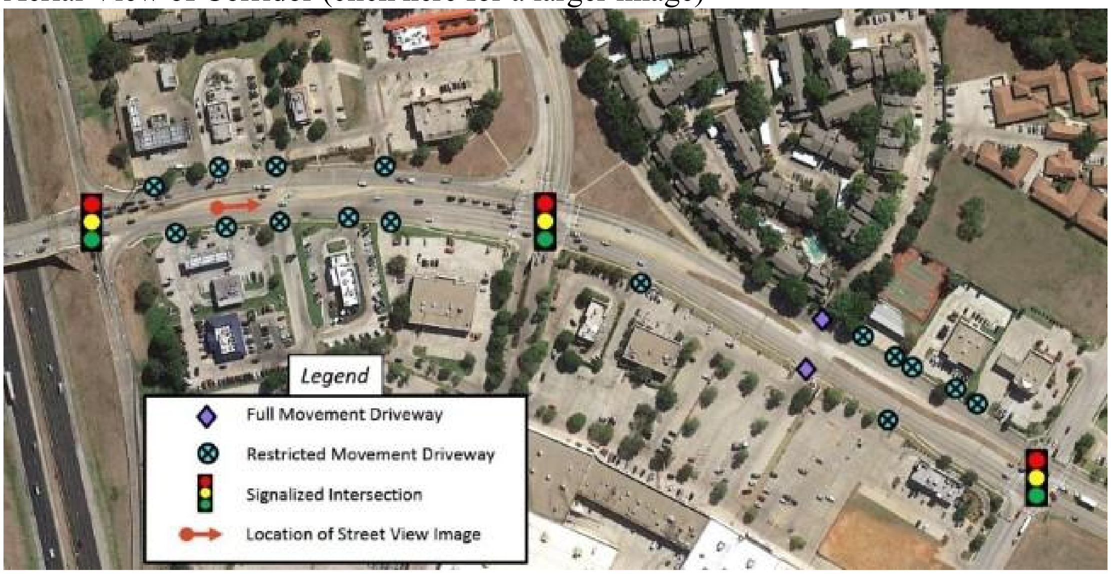
- ❍ Yes, I am a licensed professional engineer.
- ❍ No, I am not a licensed professional engineer.

Q5. Please indicate your years of experience within the transportation profession. _____

Please review the following information and pictures describing this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 6-Lane Arterial
- Median: Raised with Strategic Openings
- Posted Speed Limit: 40 mph
- Corridor Length: 0.38 miles
- AADT: 17,000 vpd

Aerial View of Corridor (click here for a larger image)



Street View of Corridor (click here for larger image)

Q6. Rate the level of access management on this corridor, from 1 – 5:

- ❍ 1 - (Poor or Non-Existent)
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5 - (Excellent)

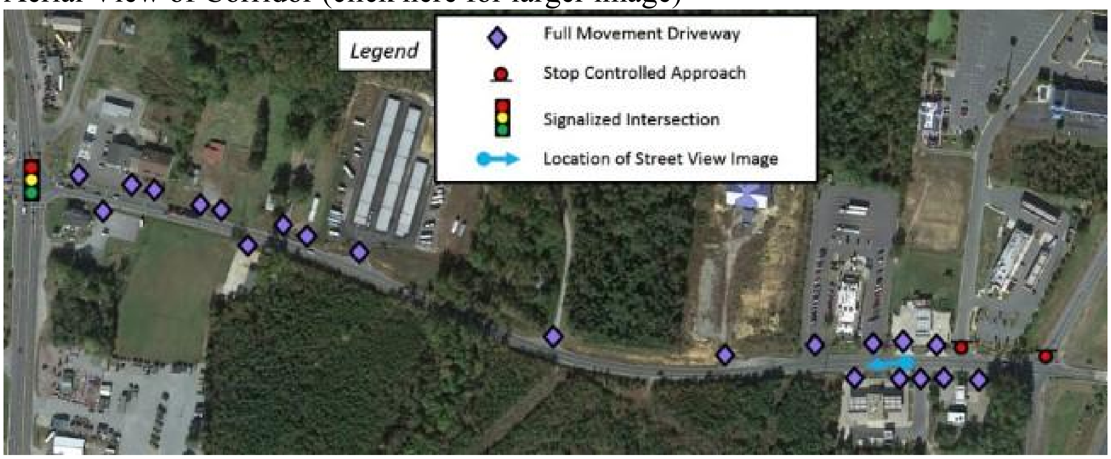
Q7. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

- ❑ Driveway Density/Spacing
- ❑ Median Type
- ❑ Signal Density/Spacing
- ❑ Land Use
- ❑ Site Development
- ❑ Bike/Ped Facilities
- ❑ Transit Facilities
- ❑ Roadway Geometry
- ❑ Traffic Volume
- ❑ Other (please specify): ____________________

Please review the following information and pictures of this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 2-Lane Highway
- Median: None
- Posted Speed Limit: 35 mph
- Corridor Length: 0.51 miles
- AADT: 12,000 vpd

Aerial View of Corridor (click here for larger image)



Street View of Corridor (click here for larger image)

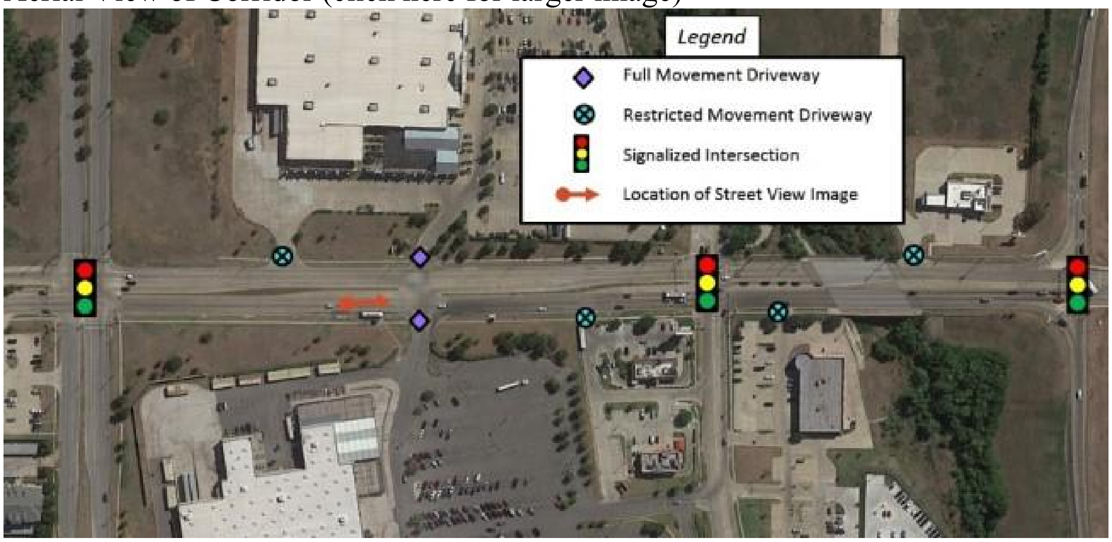
Q8. Rate the level of access management on this corridor, from 1 – 5:
- ❍ 1 - (Poor or Non-Existent)
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5 - (Excellent)

Q9. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.
- ❑ Driveway Density/Spacing
- ❑ Median Type
- ❑ Signal Density/Spacing
- ❑ Land Use
- ❑ Site Development
- ❑ Bike/Ped Facilities
- ❑ Transit Facilities
- ❑ Roadway Geometry
- ❑ Traffic Volume
- ❑ Other (please specify): ____________________

Please review the following information and pictures of this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 6-Lane Arterial
- Median: Raised with Strategic Openings
- Posted Speed Limit: 40 mph
- Corridor Length: 0.35 miles
- AADT: 12,100 vpd

Aerial View of Corridor (click here for larger image)



Street View of Corridor (click here for larger image)

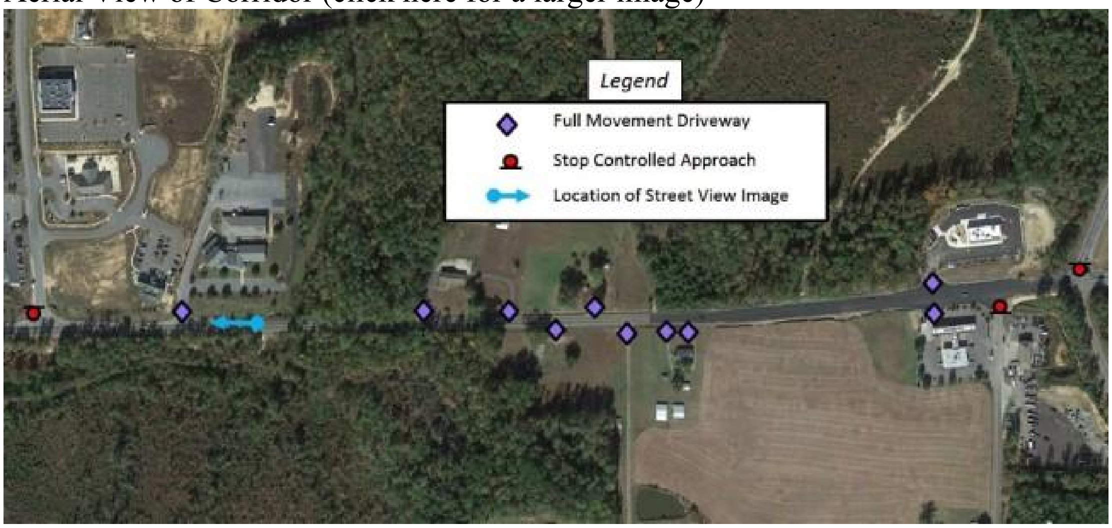
Q10. Rate the level of access management on this corridor, from 1 – 5:
- ❍ 1 - (Poor or Non-Existent)
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5 - Excellent

Q11. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.
- ❑ Driveway Density/Spacing
- ❑ Median Type
- ❑ Signal Density/Spacing
- ❑ Land Use
- ❑ Site Development
- ❑ Bike/Ped Facilities
- ❑ Transit Facilities
- ❑ Roadway Geometry
- ❑ Traffic Volume
- ❑ Other (please specify): ____________________

Please review the following information and pictures describing this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 2-Lane Highway
- Median: None
- Posted Speed Limit: 45 mph
- Corridor Length: 0.51 miles
- AADT: 12,000 vpd

Aerial View of Corridor (click here for a larger image)



Street View of Corridor (click here for larger image)

Q12. Rate the level of access management on this corridor, from 1 – 5:

- ❍ 1 - (Poor or Non-Existent)
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5 - (Excellent)

Q13. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

- ❑ Driveway Density/Spacing
- ❑ Median Type
- ❑ Signal Density/Spacing
- ❑ Land Use
- ❑ Site Development
- ❑ Bike/Ped Facilities
- ❑ Transit Facilities
- ❑ Roadway Geometry
- ❑ Traffic Volume
- ❑ Other (please specify): ____________________

Please review the following information and pictures describing this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 5-Lane Arterial
- Median: Two-Way Left-Turn Lane
- Posted Speed Limit: 40 mph
- Corridor Length: 0.43 miles
- AADT: 39,800 vpd

Aerial View of Corridor (click here for a larger image)

Street View of Corridor (click here for larger image)

Q14. Rate the level of access management on this corridor, from 1 – 5:
❍ 1 - (Poor or Non-Existent)
❍ 2
❍ 3
❍ 4
❍ 5 - (Excellent)

Q15. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.
❑ Driveway Density/Spacing
❑ Median Type
❑ Signal Density/Spacing
❑ Land Use
❑ Site Development
❑ Bike/Ped Facilities
❑ Transit Facilities
❑ Roadway Geometry
❑ Traffic Volume
❑ Other (please specify): ____________________

Please review the following information and pictures describing this corridor, then answer the questions at the bottom of this page.

- Corridor Information: 6-Lane Arterial
- Median: Painted with Strategic Openings, Two-Way Left-Turn Lane
- Posted Speed Limit: 40 mph
- Corridor Length: 0.41 miles
- AADT: 10,000 vpd

Aerial View of Corridor (click here for a larger image)

Street View of Corridor (click here for larger image)

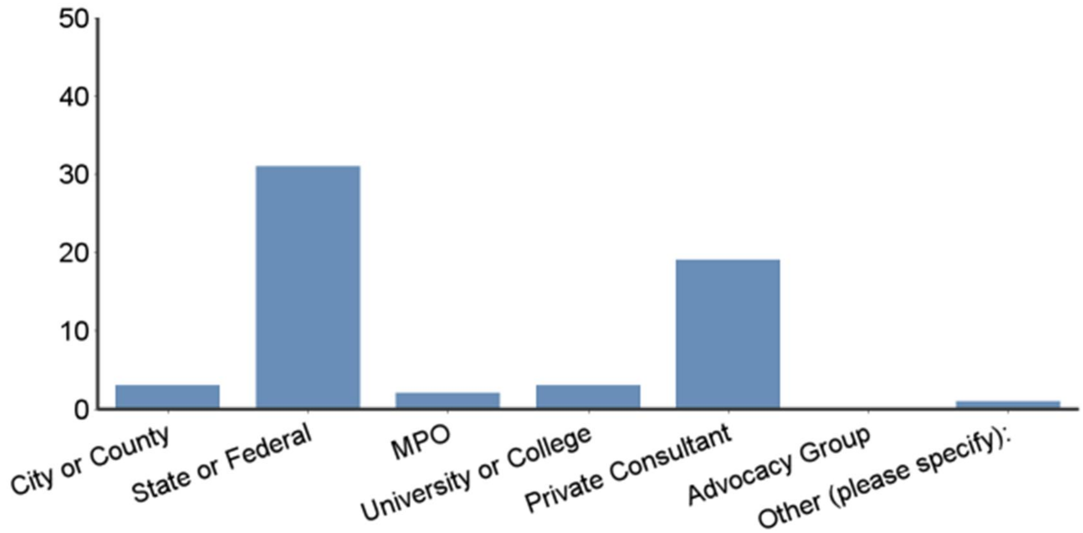
Q16. Rate the level of access management on this corridor, from 1 – 5:
- ❍ 1 - (Poor or Non-Existent)
- ❍ 2
- ❍ 3
- ❍ 4
- ❍ 5 - (Excellent)

Q17. What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.
- ❑ Driveway Density/Spacing
- ❑ Median Type
- ❑ Signal Density/Spacing
- ❑ Land Use
- ❑ Site Development
- ❑ Bike/Ped Facilities
- ❑ Transit Facilities
- ❑ Roadway Geometry
- ❑ Traffic Volume
- ❑ Other (please specify): ____________________

Q18. Please share any additional thoughts or information you may have regarding this survey.

Survey Results Report

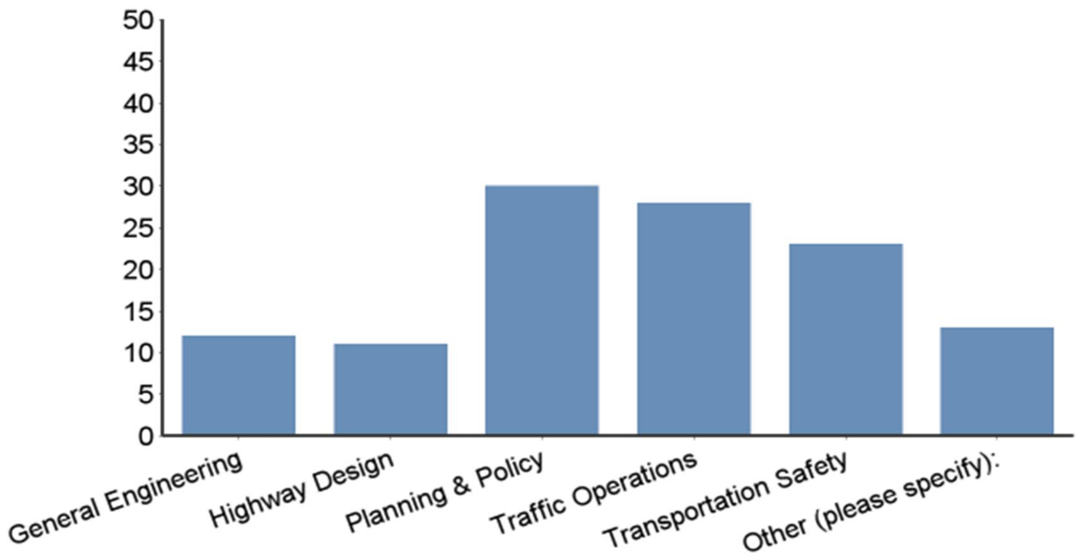
Please indicate which option best describes your current, or most recent, place of employment.



#	Answer	Bar	Response	%
1	City or County Government		3	5.08%
2	State or Federal		31	52.54%
3	Metropolitan Planning Organization		2	3.39%
4	University or College		3	5.08%
5	Private Consultant		19	32.20%
6	Advocacy Group		0	0.00%
7	Other (please specify):		1	1.69%
	Total		59	100.00%

Other (please specify):
Research

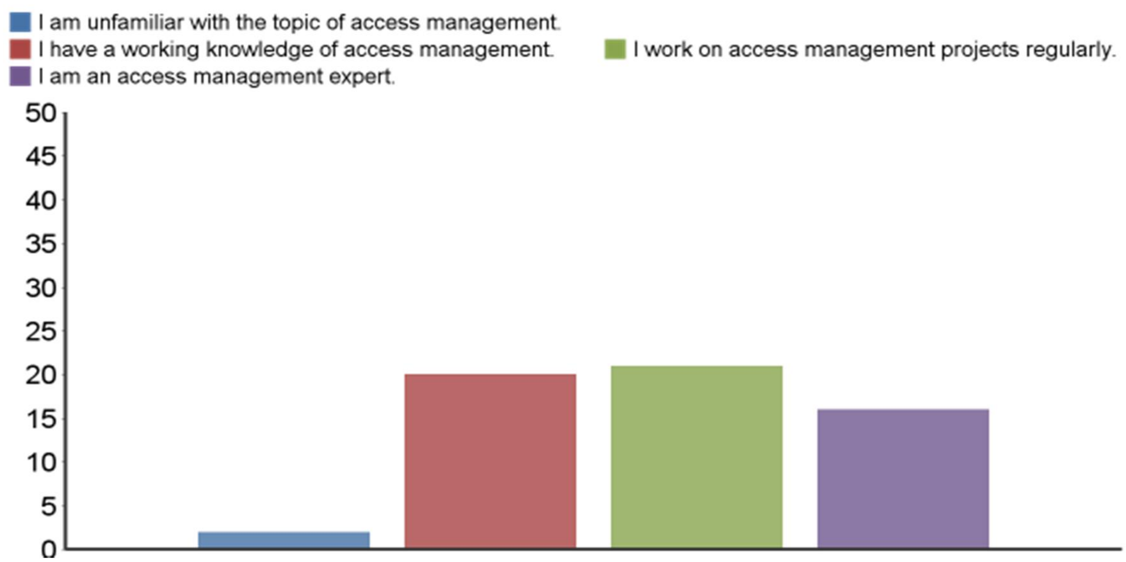
Please identify your area of practice within the transportation profession (select all that apply).



#	Answer	Bar	Response	%
1	General Engineering		12	20.34%
2	Highway Design		11	18.64%
3	Planning & Policy		30	50.85%
4	Traffic Operations		28	47.46%
5	Transportation Safety		23	38.98%
6	Other (please specify):		13	22.03%
	Total		117	100.00%

Other (please specify):
Land Development Planning and Engineering
Permitting
Access Management
Land Use
Permits and Street Acceptance
Uniform Act / Land Use Coordination
access management
Transp and Land Development
Site Plan Review
Current Planning

Please indicate your experience with the concepts and principles of access management.

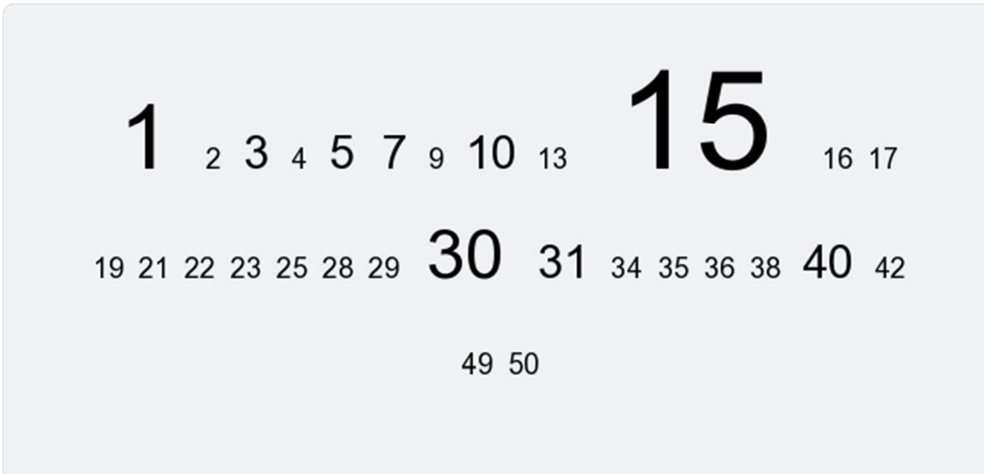


#	Answer	Bar	Response	%
1	I am unfamiliar with the topic of access management.		2	3.39%
2	I have a working knowledge of access management.		20	33.90%
3	I work on access management projects regularly.		21	35.59%
4	I am an access management expert.		16	27.12%
	Total		59	100.00%

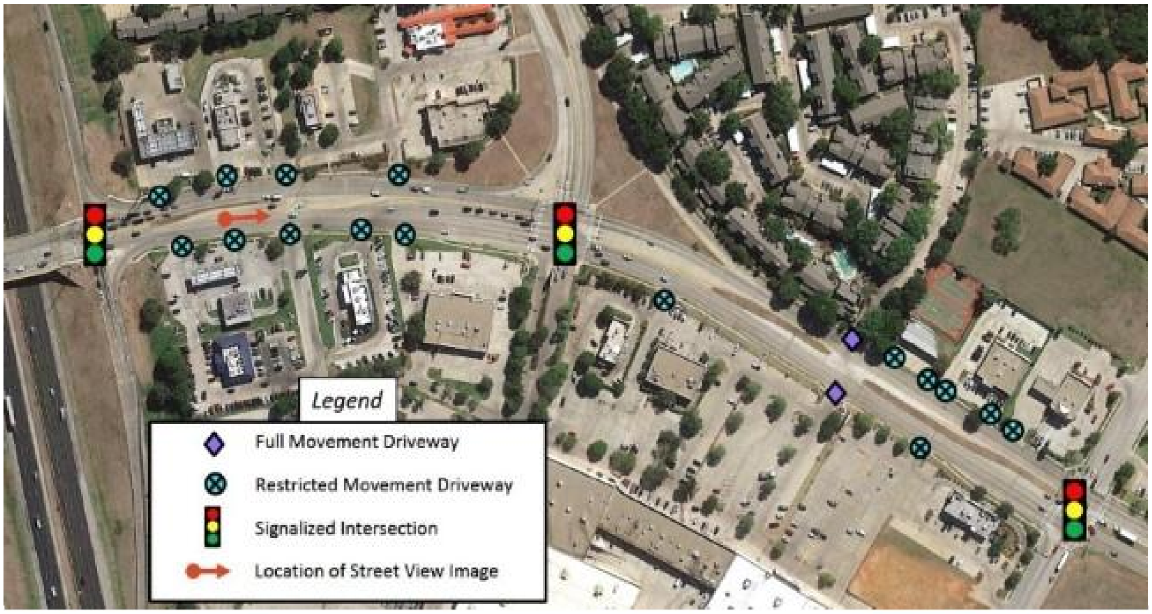
Are you a licensed professional engineer or your country’s equivalent?

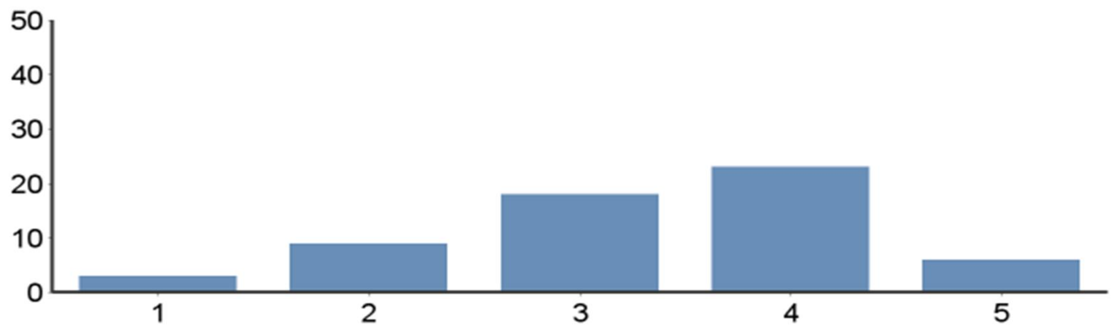
#	Answer	Bar	Response	%
1	Yes, I am a licensed professional engineer.		28	47.46%
2	No, I am not a licensed professional engineer.		31	52.54%
	Total		59	100.00%

Please indicate your years of experience within the transportation profession.



Min Value	Max Value	Average Value	StdDev	Total Respondents
1	50	19.81	13.58	59





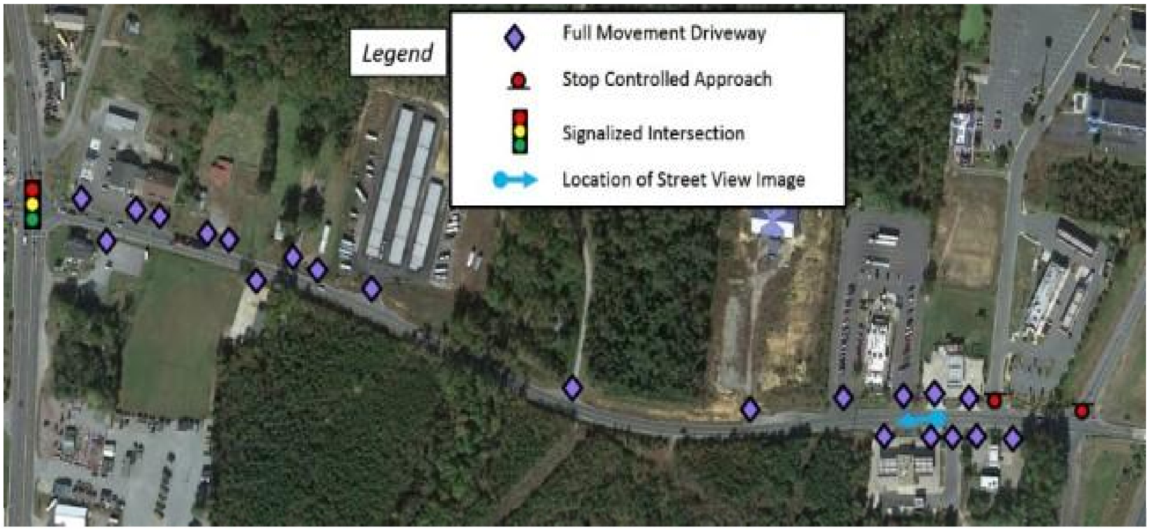
#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		3	5.08%
2	2		9	15.25%
3	3		18	30.51%
4	4		23	38.98%
5	5		6	10.17%
	Total		59	100.00%

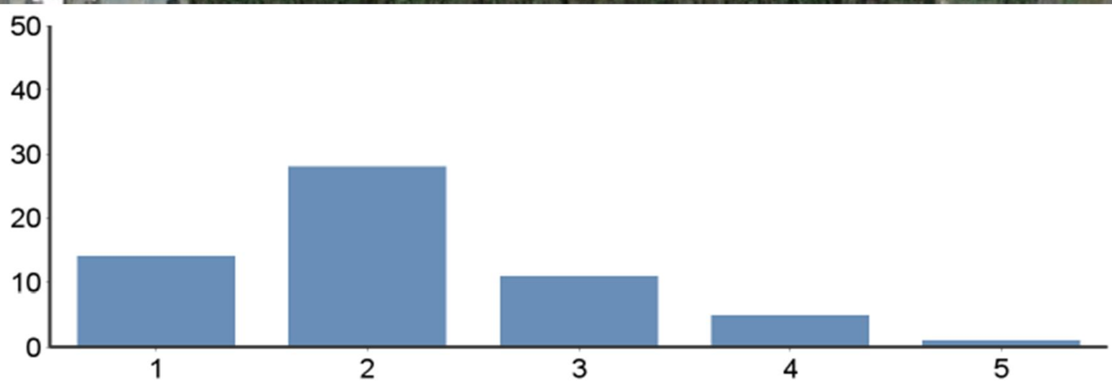
Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	5	3.34	1.06	1.03	59	59

What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

#	Answer	Bar	Response	%
1	Driveway Density/Spacing		46	77.97%
2	Median Type		33	55.93%
3	Signal Density/Spacing		19	32.20%
4	Land Use		10	16.95%
5	Site Development		18	30.51%
6	Bike/Ped Facilities		4	6.78%
7	Transit Facilities		1	1.69%
8	Roadway Geometry		11	18.64%
9	Other (please specify):		10	16.95%
10	Traffic Volume		12	20.34%
	Total		164	100.00%

Other (please specify):
driveway type
Backage road would have reduced the need for right-in-right-out
median opening spacing
Provision for RI-RO turns clear of through lanes
Cross-parcel access
proximity to interchange (appears), median opening spacing, typical section (low volume for 6-lane)
A retro-fit where access mgmt was not as agressive as possible. 2 left tun bays underdesigned, close driveway spacing. At 17,000 road is too wide and fast which decreases safety.
Driveway type
driveway movements allowed
Strippiing





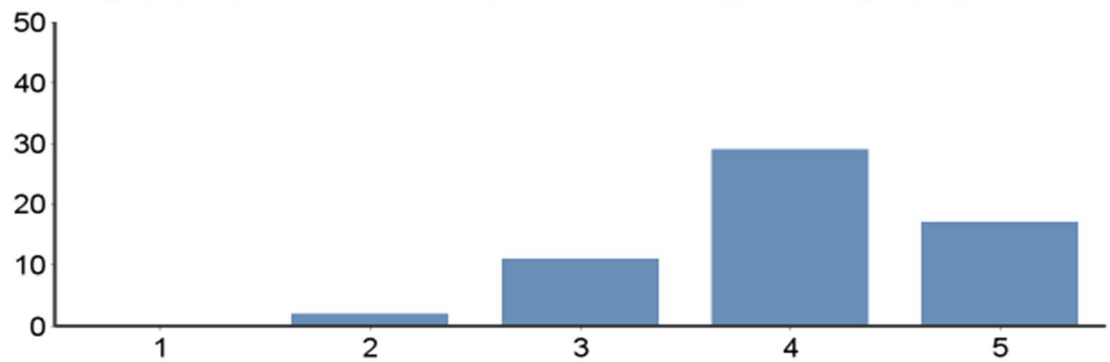
#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		14	23.73%
2	2		28	47.46%
3	3		11	18.64%
4	4		5	8.47%
5	5		1	1.69%
	Total		59	100.00%

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	5	2.17	0.90	0.95	59	59

What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

#	Answer	Bar	Response	%
1	Driveway Density/Spacing		54	91.53%
2	Median Type		9	15.25%
3	Signal Density/Spacing		5	8.47%
4	Land Use		21	35.59%
5	Site Development		25	42.37%
6	Bike/Ped Facilities		4	6.78%
7	Transit Facilities		0	0.00%
8	Roadway Geometry		15	25.42%
9	Other (please specify):		7	11.86%
10	Traffic Volume		17	28.81%
	Total		157	100.00%

Other (please specify):
No secondary roads, all abutters get full movement, plenty of frontage to add many more driveways
sight distance
Mail box in near a turn lane?, limited evelopment but accesses everywhere
Signal to Driveway Spacing
dway clusteres at each end; middle not so bad
Posted Speed
approach density will become poor with additional development



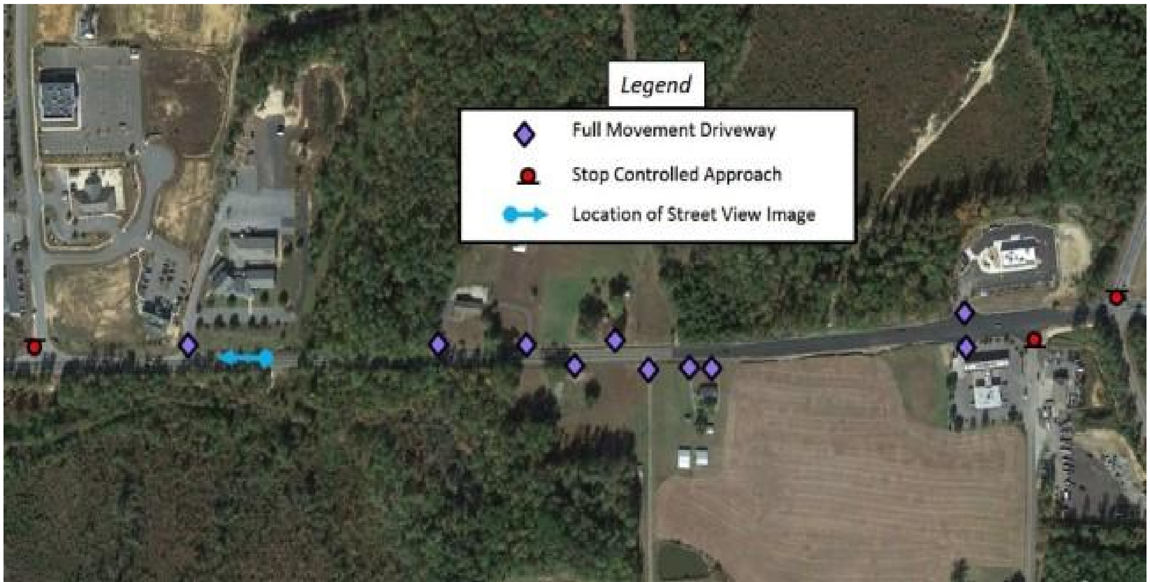
#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		0	0.00%
2	2		2	3.39%
3	3		11	18.64%
4	4		29	49.15%
5	5		17	28.81%
	Total		59	100.00%

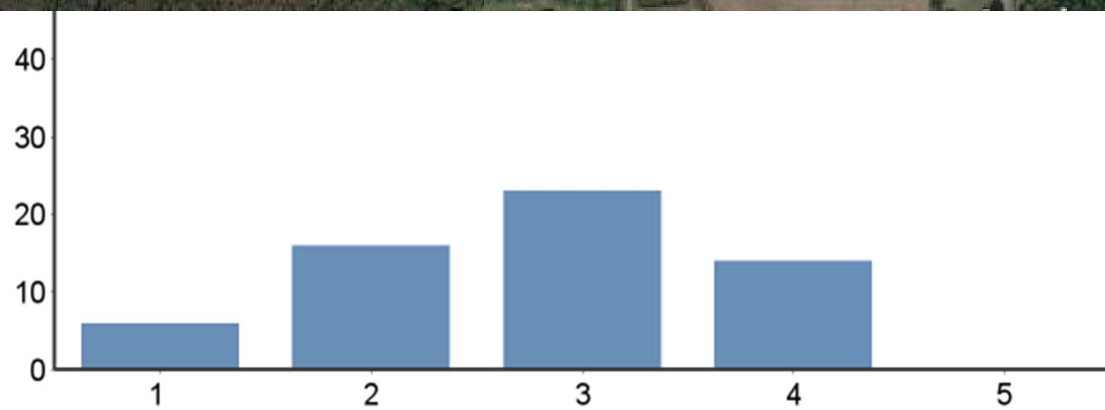
Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
2	5	4.03	0.62	0.79	59	59

What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

#	Answer	Bar	Response	%
1	Driveway		45	76.27%
2	Median Type		37	62.71%
3	Signal Density/Spacing		22	37.29%
4	Land Use		3	5.08%
5	Site Development		17	28.81%
6	Bike/Ped Facilities		5	8.47%
7	Transit Facilities		7	11.86%
8	Roadway Geometry		6	10.17%
10	Other (please specify):		8	13.56%
11	Traffic Volume		13	22.03%
	Total		163	100.00%

Other (please specify):
Access points on the main line and side roads?
median opening spacing
If this is buildout condition this would rate as excellent
Restricted movements at driveways
Pavement Markings
Road too wide for 12k, full movement out at picture is poor, bridge turn lane underdesigned, volume increase will increase crashes at Lowe's.
Sight Distance
types of movements allowed at driveways





#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		6	10.17%
2	2		16	27.12%
3	3		23	38.98%
4	4		14	23.73%
5	5		0	0.00%
	Total		59	100.00%

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	4	2.76	0.87	0.93	59	59

What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

8	Roadway Geometry		14	23.73%
9	Other (please specify):		9	15.25%
10	Traffic Volume		21	35.59%
	Total		145	100.00%

Other (please specify):

#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		6	10.17%
2	2		15	25.42%
3	3		27	45.76%
4	4		11	18.64%
5	5		0	0.00%
	Total		59	100.00%

lack of median

movements allowed at driveways

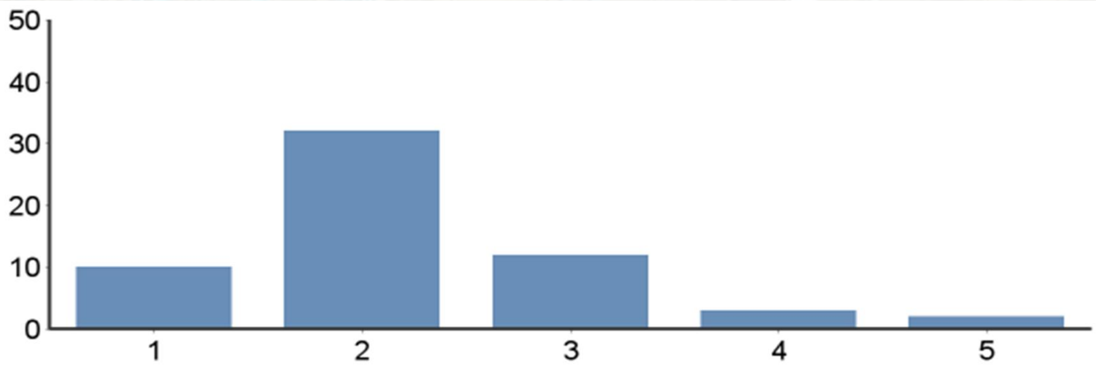
lots of driveways but probably very little driveway traffic

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	4	2.73	0.79	0.89	59	59

What factors affected your rating most significantly? (Select up to three.) Click here to review terms and definitions in a new window.

#	Answer	Bar	Response	%
1	Driveway Density/Spacing		44	74.58%
2	Median Type		31	52.54%
3	Signal Density/Spacing		10	16.95%
4	Land Use		16	27.12%
5	Site Development		16	27.12%
6	Bike/Ped Facilities		3	5.08%
7	Transit Facilities		1	1.69%
8	Roadway Geometry		10	16.95%
9	Other (please specify):		10	16.95%
10	Traffic Volume		26	44.07%
	Total		167	100.00%

Other (please specify):
TWLTL looks sub-standard
AM is good on east half, poor on west half
Full driveway movement crossig 5 lanes
very poor ped access; volume too high for flush median
very high volume for TWLTL
Only a little control of commerical, but residential has internal circulation. At 40k 40 mph it is poor
Sight Distance
Driveway movements allowed
Driveways are not close to signals
Posted Speed



#	Answer	Bar	Response	%
1	1 - (Poor or Non-Existent)		10	16.95%
2	2		32	54.24%
3	3		12	20.34%
4	4		3	5.08%
5	5		2	3.39%
	Total		59	100.00%

Min Value	Max Value	Average Value	Variance	Standard Deviation	Total Responses	Total Respondents
1	5	2.24	0.84	0.92	59	59

Please share any additional thoughts or information you may have regarding this survey.

Text Entry
More information is needed to adequately answer the questions.
Interesting.
One of the better surveys I have taken lately. Sorry, not a Johnny Manziel fan :-)
responses need explanation. We (CDTC) have a process in place to measure overall level of access management in a corridor. We offered it to the Committee many years ago - no one was interested.
Stripping and signing to restrict movements is only asking for people to interfer with flow. People are to nice and SFR suffers. It is only affective when traffic flow prevents the restricted movement.
Too few types of driveways concerning their functions and geometry are included in the interview. mmmmmmmmmmmmmmmmmmmm
Thank you.
Was not clear on the difference between Land Use and Site Development - consdier them equal in my answers, one in the same.
I would have like to had a couple of other street view shots of the corridor to really look at the access.
Access managment has a closer relationship to land use planning than engineering. If the land use and site design are carefully thought out there will be less "engineering out the problems" later down the road.
It is 4 lane, poor median design, more that 1 driveway per property, too wide for volume, Google

Statistic	Value
Respondents	19

turn movements by the signalized intersection
Driveways close to signal

APPENDIX C: SUMMARY SHEETS OF COLLECTED DATA AT STUDY LOCATIONS

Data Collection Sheets

The following pages include summary data collection sheets for each of the 16 interchange locations. Each site is summarized in three pages, which include the following data:

Page 1: General interchange information including aerial and street-view photos

Page 2: Collected data for the South or East side of the interchange, including:

- Roadway data
- Interchange Data
- Driveway Data
- Land Use Data
- Safety Data
- Accessibility Data

Page 3: Collected data for the North or West side of the interchange (same as above)

Site: AR #1: Partial Cloverleaf

West

aerial image of entire corridor

West

street-view of corridor cross-section

Interchange Type:	Partial-Cloverleaf	**East Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Yield

Site: AR #1: Partial Cloverleaf

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.34
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	25.3
Roadway Volume (AADT):	41,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	54.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	197.3
ntersection Control Type:	2-Way Stop

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	196.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	4
Signals per Mile:	*5.8*
Intersections per Mile:	*17.5*
Full Movement Driveways:	10
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*29.1*
Minimum Driveway Spacing (ft):	36.9
Maximum Driveway Spacing (ft):	347.6

Land Use Data

Land Use Type:

Commercial (Percentage):	80%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	20%
Total (Percentage):	*100%*
Number of Developed Parcels:	14
Average DWs per Parcel:	*0.71*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*20.39*
Average Crash Rate:	*30.27*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	30%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*2.91*
Crosswalks per Intersection:	*0.17*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.18
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	23.6
Roadway Volume (AADT):	34,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	145.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	89.6
ntersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	306.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	1
Signals per Mile:	*11.3*
Intersections per Mile:	*16.9*
Full Movement Driveways:	7
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*39*
Minimum Driveway Spacing (ft):	18.9
Maximum Driveway Spacing (ft):	82.6

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	6
Average DWs per Parcel:	*1.17*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*11.27*
Average Crash Rate:	*30.27*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	25%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*5.64*
Crosswalks per Intersection:	*0.33*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: AR #2: Stop Controlled Diamond

aerial image of entire corridor

South

street-view of corridor cross-section

North

Interchange Type:	Diamond	**North Terminal Right Turn Type:**	Yield
Terminal Control Type:	2-Way Stop	**South Terminal Right Turn Type:**	Yield

Site: AR #2: Stop Controlled Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.13
Endpoint Type:	Unsignalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	31
Roadway Volume (AADT):	8,800
Number of Through Lanes:	2
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:	
Nearest DS Driveway (ft):	208.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	197.9
ntersection Control Type:	2-Way Stop
Distance from EB On-Ramp to:	
Nearest US Driveway (ft):	222.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:	
Signalized Intersections:	0
Unsignalized Intersections:	3
Signals per Mile:	*0*
Intersections per Mile:	*23.5*
Full Movement Driveways:	6
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*46.9*
Minimum Driveway Spacing (ft):	24.1
Maximum Driveway Spacing (ft):	160.3

Land Use Data

Land Use Type:	
Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	4
Average DWs per Parcel:	*1.50*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A,B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*54.76*
Average Crash Rate:	*390.31*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
Number of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:	
Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.16
Endpoint Type:	Driveway
Roadway Posted Speed (mph):	55
Roadway Operating Speed (mph):	46.9
Roadway Volume (AADT):	2,900
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Ra	
Nearest DS Driveway (ft):	250.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	-
ntersection Control Type:	Other
Distance from WB On-Ra	
Nearest US Driveway (ft):	173.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	0
Unsignalized Intersections:	1
Signals per Mile:	*0*
Intersections per Mile:	*6.2*
Full Movement Driveways:	8
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*50*
Minimum Driveway Spacing (ft):	24.1
Maximum Driveway Spacing (ft):	109.5

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	6
Average DWs per Parcel:	*1.33*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A,B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*12.39*
Average Crash Rate:	*390.31*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
Number of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: AR #3: Signalized Diamond

aerial image of entire corridor

West

street-view of corridor cross-section

West

Interchange Type:	Diamond	**East Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Yield

Site: AR #3: Signalized Diamond

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.11
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	22.9
Roadway Volume (AADT):	33,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	80%
Median Type (2):	Raised
(Percentage):	20%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	131.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	588.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	197.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*18.2*
Intersections per Mile:	*18.2*
Full Movement Driveways:	6
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*54.5*
Minimum Driveway Spacing (ft):	26.2
Maximum Driveway Spacing (ft):	152.3

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	5
Average DWs per Parcel:	*1.20*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*209.09*
Average Crash Rate:	*492.72*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	50%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*9.09*
Crosswalks per Intersection:	*0.50*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.15
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	25.5
Roadway Volume (AADT):	29,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ram	
Nearest DS Driveway (ft):	144.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	779.0
ntersection Control Type:	Signal
Distance from SB On-Ram	
Nearest US Driveway (ft):	128.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	3
Signals per Mile:	*13.6*
Intersections per Mile:	*34*
Full Movement Driveways:	13
3/4 Movement Driveways:	0
RIRO Driveways:	1
Driveways per Mile:	*95*
Minimum Driveway Spacing (ft):	30.0
Maximum Driveway Spacing (ft):	138.3

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	10
Average DWs per Parcel:	*1.40*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*156.46*
Average Crash Rate:	*492.72*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa	
Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: AR #4: Signalized Diamond

aerial image of entire corridor

West

street-view of corridor cross-section

East

Interchange Type:	Diamond	**East Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Yield

Site: AR #4: Signalized Diamond

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.08
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	7.8
Roadway Volume (AADT):	32,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	155.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	433.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	202.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*24.4*
Intersections per Mile:	*24.4*
Full Movement Driveways:	3
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*36.6*
Minimum Driveway Spacing (ft):	93.9
Maximum Driveway Spacing (ft):	124.7

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	4
Average DWs per Parcel:	*0.75*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*85.36*
Average Crash Rate:	*15.38*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.34
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	18.4
Roadway Volume (AADT):	35,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	251.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	245.8
ntersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	280.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	3
Signals per Mile:	*5.9*
Intersections per Mile:	*14.7*
Full Movement Driveways:	14
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*41*
Minimum Driveway Spacing (ft):	55.4
Maximum Driveway Spacing (ft):	228.8

Land Use Data

Land Use Type:

Commercial (Percentage):	90%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	10%
Total (Percentage):	*100%*
Number of Developed Parcels:	14
Average DWs per Parcel:	*1.00*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*5.89*
Average Crash Rate:	*15.38*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*2.95*
Crosswalks per Intersection:	*0.20*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	1
Percent of Parcels w/ Sidewalks:	*7%*

Site: AZ #1: Signalized Diamond

aerial image of entire corridor

North

street-view of corridor cross-section

North

Interchange Type:	Diamond	**North Terminal Right Turn Type:**	Signal
Terminal Control Type:	Signal	**South Terminal Right Turn Type:**	Signal

Site: AZ #1: Signalized Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.21
Endpoint Type:	Unsignalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	21.7
Roadway Volume (AADT):	27,600
Number of Through Lanes:	4
Median Type (1):	Raised
(Percentage):	20%
Median Type (2):	TWLTL
(Percentage):	80%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:

Nearest DS Driveway (ft):	276.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	1088.0
ntersection Control Type:	2-Way Stop

Distance from EB On-Ramp to:

Nearest US Driveway (ft):	135.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	2
Signals per Mile:	*4.9*
Intersections per Mile:	*14.6*
Full Movement Driveways:	11
3/4 Movement Driveways:	1
RIRO Driveways:	0
Driveways per Mile:	*58.2*
Minimum Driveway Spacing (ft):	51.6
Maximum Driveway Spacing (ft):	413.3

Land Use Data

Land Use Type:

Commercial (Percentage):	10%
Industrial (Percentage):	90%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	10
Average DWs per Parcel:	*1.20*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*33.97*
Average Crash Rate:	*42.29*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*9.71*
Crosswalks per Intersection:	*0.67*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	3
Percent of Parcels w/ Sidewalks:	*30%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.23
Endpoint Type:	Unsignalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	28.2
Roadway Volume (AADT):	18,800
Number of Through Lanes:	4
Median Type (1):	Raised
(Percentage):	15%
Median Type (2):	TWLTL
(Percentage):	85%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Ramp to:

Nearest DS Driveway (ft):	123.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	880.0
ntersection Control Type:	2-Way Stop

Distance from WB On-Ramp to:

Nearest US Driveway (ft):	525.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	5
Signals per Mile:	*4.4*
Intersections per Mile:	*26.1*
Full Movement Driveways:	10
3/4 Movement Driveways:	0
RIRO Driveways:	1
Driveways per Mile:	*48*
Minimum Driveway Spacing (ft):	37.5
Maximum Driveway Spacing (ft):	523.4

Land Use Data

Land Use Type:

Commercial (Percentage):	5%
Industrial (Percentage):	25%
Residential (Percentage):	70%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	21
Average DWs per Parcel:	*0.52*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*8.71*
Average Crash Rate:	*42.29*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*8.71*
Crosswalks per Intersection:	*0.33*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

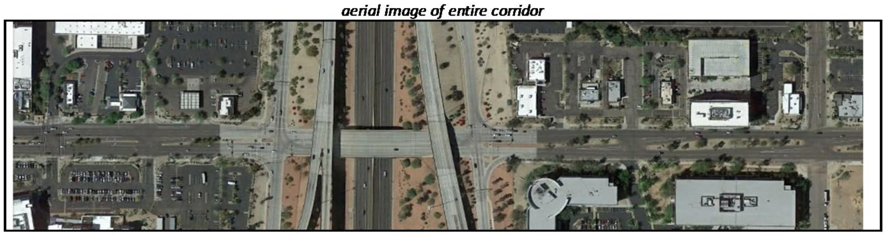
Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	2
Percent of Parcels w/ Sidewalks:	*10%*

Site: AZ #2: Signalized Diamond

South

aerial image of entire corridor



North

street-view of corridor cross-section

Interchange Type:	Diamond	**North Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**South Terminal Right Turn Type:**	Signal

Site: AZ #2: Signalized Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.13
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	12.1
Roadway Volume (AADT):	20,000
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:

Nearest DS Driveway (ft):	195.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	703.0
ıtersection Control Type:	Signal

Distance from EB On-Ramp to:

Nearest US Driveway (ft):	400.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*15*
Intersections per Mile:	*15*
Full Movement Driveways:	2
3/4 Movement Driveways:	0
RIRO Driveways:	1
Driveways per Mile:	*22.5*
Minimum Driveway Spacing (ft):	151.6
Maximum Driveway Spacing (ft):	393.0

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	6
Average DWs per Parcel:	*0.50*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*172.75*
Average Crash Rate:	*512.50*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*15.02*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	6
Percent of Parcels w/ Sidewalks:	*100%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.20
Endpoint Type:	Unsignalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	24.7
Roadway Volume (AADT):	20,000
Number of Through Lanes:	4
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Ra

Nearest DS Driveway (ft):	473.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	1082.0
ntersection Control Type:	2-Way Stop

Distance from WB On-Rar

Nearest US Driveway (ft):	246.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	1
Signals per Mile:	*4.9*
Intersections per Mile:	*9.8*
Full Movement Driveways:	2
3/4 Movement Driveways:	0
RIRO Driveways:	2
Driveways per Mile:	*20*
Minimum Driveway Spacing (ft):	213.0
Maximum Driveway Spacing (ft):	373.5

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	8
Average DWs per Parcel:	*0.50*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*112.24*
Average Crash Rate:	*512.50*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*4.88*
Crosswalks per Intersection:	*0.50*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	8
Percent of Parcels w/ Sidewalks:	*100%*

Site: AZ #3: SPUI

West

aerial image of entire corridor

East

street-view of corridor cross-section

Interchange Type:	SPUI	**East Terminal Right Turn Type:**	Signal
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Signal

Site: AZ #3: SPUI

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.19
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	16.5
Roadway Volume (AADT):	44,700
Number of Through Lanes:	6
Median Type (1):	Painted
(Percentage):	50%
Median Type (2):	Raised
(Percentage):	5%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	334.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	1017.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	211.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*10.5*
Intersections per Mile:	*10.5*
Full Movement Driveways:	11
3/4 Movement Driveways:	1
RIRO Driveways:	1
Driveways per Mile:	*68.4*
Minimum Driveway Spacing (ft):	10.0
Maximum Driveway Spacing (ft):	273.0

Land Use Data

Land Use Type:

Commercial (Percentage):	92%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	8%
Total (Percentage):	*100%*
Number of Parcels:	10
Average DWs per Parcel:	*1.30*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*36.84*
Average Crash Rate:	*20.50*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	7
Crosswalks per Mile:	*36.84*
Crosswalks per Intersection:	*3.50*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	5
Percent of Parcels w/ Sidewalks:	*50%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.22
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	15.6
Roadway Volume (AADT):	40,500
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	30%
Median Type (2):	Painted
(Percentage):	60%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	74.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	546.0
ıtersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	95.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*9.1*
Intersections per Mile:	*9.1*
Full Movement Driveways:	9
3/4 Movement Driveways:	1
RIRO Driveways:	7
Driveways per Mile:	*77*
Minimum Driveway Spacing (ft):	17.0
Maximum Driveway Spacing (ft):	237.0

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	11
Average DWs per Parcel:	*1.55*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*9.09*
Average Crash Rate:	*20.50*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	7
Crosswalks per Mile:	*31.82*
Crosswalks per Intersection:	*3.50*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	2
Percent of Parcels w/ Sidewalks:	*18%*

Site: AZ #4: Roundabout

aerial image of entire corridor

West

street-view of corridor cross-section

East

Interchange Type:	Roundabout	**East Terminal Right Turn Type:**	Yield
Terminal Control Type:	Other	**West Terminal Right Turn Type:**	Yield

Site: AZ #4: Roundabout

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.14
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	11.2
Roadway Volume (AADT):	15,600
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	328.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	722.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	328.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	1
Signals per Mile:	*7.3*
Intersections per Mile:	*14.6*
Full Movement Driveways:	0
3/4 Movement Driveways:	0
RIRO Driveways:	2
Driveways per Mile:	*14.6*
Minimum Driveway Spacing (ft):	325.0
Maximum Driveway Spacing (ft):	349.6

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	6
Average DWs per Parcel:	*0.33*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*51.19*
Average Crash Rate:	*6.54*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*14.63*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	6
Percent of Parcels w/ Sidewalks:	*100%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.84
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	28.5
Roadway Volume (AADT):	33,400
Number of Through Lanes:	6
Median Type (1):	TWLTL
(Percentage):	20%
Median Type (2):	Raised
(Percentage):	80%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	560.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	4414.0
ntersection Control Type:	Signal

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	374.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	2
Signals per Mile:	*1.2*
Intersections per Mile:	*3.6*
Full Movement Driveways:	1
3/4 Movement Driveways:	1
RIRO Driveways:	1
Driveways per Mile:	*4*
Minimum Driveway Spacing (ft):	368.4
Maximum Driveway Spacing (ft):	1683.1

Land Use Data

Land Use Type:

Commercial (Percentage):	0%
Industrial (Percentage):	10%
Residential (Percentage):	0%
Vacant (Percentage):	90%
Total (Percentage):	*100%*
Number of Parcels:	3
Average DWs per Parcel:	*1.00*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*2.39*
Average Crash Rate:	*6.54*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	95%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*2.39*
Crosswalks per Intersection:	*0.67*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: AZ #5: Signalized Diamond

aerial image of entire corridor

West

street-view of corridor cross-section

West

Interchange Type:	Diamond	**East Terminal Right Turn Type:**	Signal
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Signal

Site: AZ #5: Signalized Diamond

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.31
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	28.7
Roadway Volume (AADT):	44,100
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	80%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	305.0
Side of Road:	Right
Driveway Type:	3/4 Movement
Nearest Intersection (ft):	1640.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	342.0
Side of Road:	Right
Driveway Type:	3/4 Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	1
Signals per Mile:	*6.5*
Intersections per Mile:	*9.7*
Full Movement Driveways:	4
3/4 Movement Driveways:	4
RIRO Driveways:	6
Driveways per Mile:	*45.2*
Minimum Driveway Spacing (ft):	26.2
Maximum Driveway Spacing (ft):	152.3

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	15
Average DWs per Parcel:	*0.93*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*74.19*
Average Crash Rate:	*225.81*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*6.45*
Crosswalks per Intersection:	*0.67*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	4
Percent of Parcels w/ Sidewalks:	*27%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.22
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	19.1
Roadway Volume (AADT):	41,900
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ram	
Nearest DS Driveway (ft):	343.0
Side of Road:	Right
Driveway Type:	3/4 Movement
Nearest Intersection (ft):	1170.0
ntersection Control Type:	Signal
Distance from SB On-Ram	
Nearest US Driveway (ft):	283.0
Side of Road:	Right
Driveway Type:	3/4 Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	2
Signals per Mile:	*9*
Intersections per Mile:	*18*
Full Movement Driveways:	0
3/4 Movement Driveways:	3
RIRO Driveways:	4
Driveways per Mile:	*32*
Minimum Driveway Spacing (ft):	106.0
Maximum Driveway Spacing (ft):	170.3

Land Use Data

Land Use Type:

Commercial (Percentage):	90%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	10%
Total (Percentage):	*100%*
Number of Parcels:	10
Average DWs per Parcel:	*0.70*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	2
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	6
Number of PDO Crashes (O):	10
Total Crashes:	*23.00*
Average Crashes per Year:	*7.67*
Average Crashes per Mile per Year:	*103.60*
Average Crash Rate:	*225.81*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*13%*
Number of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*17%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	1
Percent Pedestrian Crashes:	*4%*

Accessibility Data

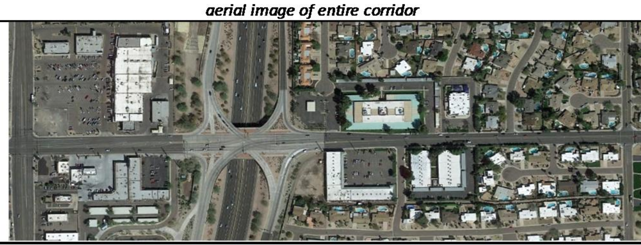
Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*9.01*
Crosswalks per Intersection:	*0.50*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	1
Percent of Parcels w/ Bike Storage:	*10%*
Continuous Sidewalks (road to door):	3
Percent of Parcels w/ Sidewalks:	*30%*

Site: AZ #6: SPUI

West

aerial image of entire corridor



East

street-view of corridor cross-section

Interchange Type:	SPUI	East Terminal Right Turn Type:	Free
Terminal Control Type:	Signal	West Terminal Right Turn Type:	Yield

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.14
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	21.5
Roadway Volume (AADT):	10,000
Number of Through Lanes:	6
Median Type (1):	Painted
(Percentage):	95%
Median Type (2):	Raised
(Percentage):	5%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	132.0
Side of Road:	Right
Driveway Type:	3/4 Movement
Nearest Intersection (ft):	742.0
ntersection Control Type:	Signal

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	105.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	1
Signals per Mile:	*14.2*
Intersections per Mile:	*21.3*
Full Movement Driveways:	2
3/4 Movement Driveways:	2
RIRO Driveways:	6
Driveways per Mile:	*71*
Minimum Driveway Spacing (ft):	39.2
Maximum Driveway Spacing (ft):	152.4

Land Use Data

Land Use Type:

Commercial (Percentage):	85%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	15%
Total (Percentage):	*100%*
Number of Parcels:	7
Average DWs per Parcel:	*1.43*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*14.23*
Average Crash Rate:	*129.97*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*7.12*
Crosswalks per Intersection:	*0.33*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	1
Percent of Parcels w/ Sidewalks:	*14%*

Site: AZ #6: SPUI

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.27
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	29.8
Roadway Volume (AADT):	39,800
Number of Through Lanes:	6
Median Type (1):	TWLTL
(Percentage):	95%
Median Type (2):	Raised
(Percentage):	5%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	426.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	1445.0
ıtersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	180.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	3
Signals per Mile:	*7.3*
Intersections per Mile:	*18.3*
Full Movement Driveways:	4
3/4 Movement Driveways:	0
RIRO Driveways:	2
Driveways per Mile:	*21.9*
Minimum Driveway Spacing (ft):	26.4
Maximum Driveway Spacing (ft):	404.3

Land Use Data

Land Use Type:

Commercial (Percentage):	0%
Industrial (Percentage):	50%
Residential (Percentage):	50%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	15
Average DWs per Parcel:	*0.40*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*25.58*
Average Crash Rate:	*129.97*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	100%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*3.65*
Crosswalks per Intersection:	*0.20*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	
Transit Stops per Mile:	*0.00*

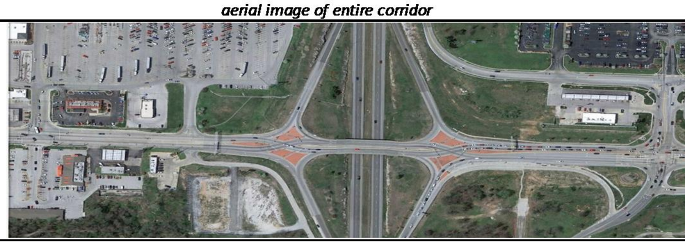
Number of Developments Providing:

Bicycle Storage:	
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	12
Percent of Parcels w/ Sidewalks:	*80%*

Site: MO #1: Diverging Diamond

aerial image of entire corridor

South



street-view of corridor cross-section

North

Interchange Type:	Diverging Diamond	**North Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**South Terminal Right Turn Type:**	Yield

Site: MO #1: Diverging Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.14
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	11.9
Roadway Volume (AADT):	20,000
Number of Through Lanes:	4
Median Type (1):	TWLTL
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:

Nearest DS Driveway (ft):	276.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	733.0
ntersection Control Type:	Signal

Distance from EB On-Ramp to:

Nearest US Driveway (ft):	282.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*14.4*
Intersections per Mile:	*14.4*
Full Movement Driveways:	4
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*28.8*
Minimum Driveway Spacing (ft):	93.9
Maximum Driveway Spacing (ft):	124.7

Land Use Data

Land Use Type:

Commercial (Percentage):	85%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	15%
Total (Percentage):	*100%*
Number of Parcels:	6
Average DWs per Parcel:	*0.67*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*50.42*
Average Crash Rate:	*74.18*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	70%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*14.41*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	1
Percent of Parcels w/ Sidewalks:	*17%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.12
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	8.1
Roadway Volume (AADT):	20,000
Number of Through Lanes:	4
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Ramp to:

Nearest DS Driveway (ft):	-
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	650.0
ntersection Control Type:	Signal

Distance from WB On-Ramp to:

Nearest US Driveway (ft):	-
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	0
Unsignalized Intersections:	1
Signals per Mile:	*0*
Intersections per Mile:	*8.1*
Full Movement Driveways:	8
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*65*
Minimum Driveway Spacing (ft):	24.1
Maximum Driveway Spacing (ft):	109.5

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	6
Average DWs per Parcel:	*1.33*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*16.25*
Average Crash Rate:	*74.18*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*8.12*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

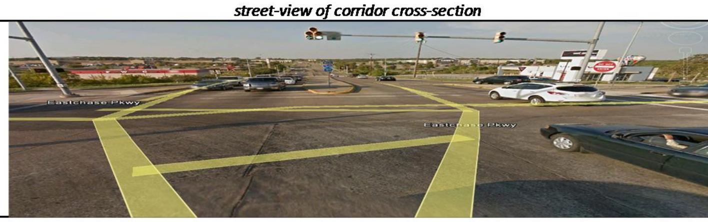
Site: TX #1: Signalized Diamond

aerial image of entire corridor

South

street-view of corridor cross-section

North



Interchange Type:	Diamond	**North Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**South Terminal Right Turn Type:**	Yield

Site: TX #1: Signalized Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.17
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	29.5
Roadway Volume (AADT):	20,000
Number of Through Lanes:	2
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:	
Nearest DS Driveway (ft):	115.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	873.0
ntersection Control Type:	Signal
Distance from EB On-Ramp to:	
Nearest US Driveway (ft):	105.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:	
Signalized Intersections:	1
Unsignalized Intersections:	0
Signals per Mile:	*5.9*
Intersections per Mile:	*5.9*
Full Movement Driveways:	0
3/4 Movement Driveways:	2
RIRO Driveways:	7
Driveways per Mile:	*52.9*
Minimum Driveway Spacing (ft):	40.0
Maximum Driveway Spacing (ft):	182.0

Land Use Data

Land Use Type:	
Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	7
Average DWs per Parcel:	*1.29*

Safety Data

Years of Data:	4
Number of Fatal Crashes (K):	0
Number of Serious Injury Crashes (A):	4
Number of Injury Crashes (B):	6
Number of Possible Injury Crashes (C):	0
Number of PDO Crashes (O):	9
Total Crashes:	*19.00*
Average Crashes per Year:	*4.75*
Average Crashes per Mile per Year:	*111.76*
Average Crash Rate:	*520.88*
Number of Driveway-Related Crashes:	0
Percent Driveway Crashes:	*0%*
Number of Intersection-Related Crashes:	0
Percent Intersection Crashes:	*0%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:	
Sidewalks (Percentage):	80%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*5.88*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.13
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	31.4
Roadway Volume (AADT):	12,138
Number of Through Lanes:	2
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Ra

Nearest DS Driveway (ft):	256.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	607.0
ntersection Control Type:	Signal

Distance from WB On-Ra

Nearest US Driveway (ft):	518.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	0
Signals per Mile:	*7.7*
Intersections per Mile:	*7.7*
Full Movement Driveways:	0
3/4 Movement Driveways:	0
RIRO Driveways:	1
Driveways per Mile:	*8*
Minimum Driveway Spacing (ft):	NA
Maximum Driveway Spacing (ft):	NA

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	2
Average DWs per Parcel:	*0.50*

Safety Data

Years of Data:	4
Number of Fatal Crashes (K):	1
Number of Serious Injury Crashes (A):	0
Number of Injury Crashes (B):	2
Number of Possible Injury Crashes (C):	0
Number of PDO Crashes (O):	9
Total Crashes:	*12.00*
Average Crashes per Year:	*3.00*
Average Crashes per Mile per Year:	*92.31*
Average Crash Rate:	*520.88*
Number of Driveway-Related Crashes:	0
Percent Driveway Crashes:	*0%*
Number of Intersection-Related Crashes:	7
Percent Intersection Crashes:	*58%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	60%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*7.69*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

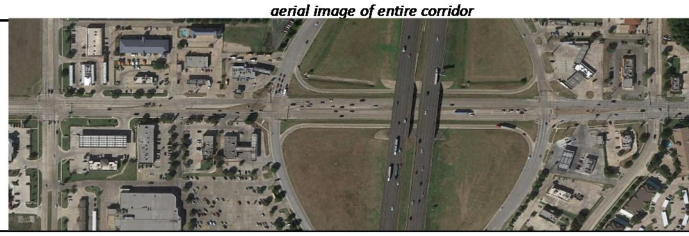
Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	2
Percent of Parcels w/ Sidewalks:	*100%*

Site: TX #2: Signalized Diamond

aerial image of entire corridor

South



street-view of corridor cross-section

North

Interchange Type:	Diamond	**North Terminal Right Turn Type:**	Yield
Terminal Control Type:	Signal	**South Terminal Right Turn Type:**	Signal

Site: TX #2: Signalized Diamond

South Side of Interchange

Roadway Data

Corridor Length (mi):	0.16
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	22.4
Roadway Volume (AADT):	20,000
Number of Through Lanes:	2
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from EB Off-Ramp to:

Nearest DS Driveway (ft):	72.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	850.0
ntersection Control Type:	Signal

Distance from EB On-Ramp to:

Nearest US Driveway (ft):	168.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	0
Signals per Mile:	*6.3*
Intersections per Mile:	*6.3*
Full Movement Driveways:	2
3/4 Movement Driveways:	0
RIRO Driveways:	6
Driveways per Mile:	*50*
Minimum Driveway Spacing (ft):	30.0
Maximum Driveway Spacing (ft):	267.0

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	8
Average DWs per Parcel:	*1.00*

Safety Data

Years of Data:	4
Number of Fatal Crashes (K):	0
Number of Serious Injury Crashes (A):	0
Number of Injury Crashes (B):	4
Number of Possible Injury Crashes (C):	10
Number of PDO Crashes (O):	18
Total Crashes:	*32.00*
Average Crashes per Year:	*8.00*
Average Crashes per Mile per Year:	*200.00*
Average Crash Rate:	*211.61*
Number of Driveway-Related Crashes:	0
Percent Driveway Crashes:	*0%*
Number of Intersection-Related Crashes:	20
Percent Intersection Crashes:	*63%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	60%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*6.25*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

North Side of Interchange

Roadway Data

Corridor Length (mi):	0.08
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	40
Roadway Operating Speed (mph):	24.7
Roadway Volume (AADT):	12,138
Number of Through Lanes:	2
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from WB Off-Rai

Nearest DS Driveway (ft):	111.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	393.0
ntersection Control Type:	Signal

Distance from WB On-Rar

Nearest US Driveway (ft):	106.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	0
Signals per Mile:	*12.5*
Intersections per Mile:	*12.5*
Full Movement Driveways:	0
3/4 Movement Driveways:	0
RIRO Driveways:	5
Driveways per Mile:	*63*
Minimum Driveway Spacing (ft):	NA
Maximum Driveway Spacing (ft):	NA

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Parcels:	4
Average DWs per Parcel:	*1.25*

Safety Data

Years of Data:	4
Number of Fatal Crashes (K):	0
Number of Serious Injury Crashes (A):	0
Number of Injury Crashes (B):	1
Number of Possible Injury Crashes (C):	0
Number of PDO Crashes (O):	2
Total Crashes:	*3.00*
Average Crashes per Year:	*0.75*
Average Crashes per Mile per Year:	*37.50*
Average Crash Rate:	*211.61*
Number of Driveway-Related Crashes:	0
Percent Driveway Crashes:	*0%*
Number of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*67%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	50%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

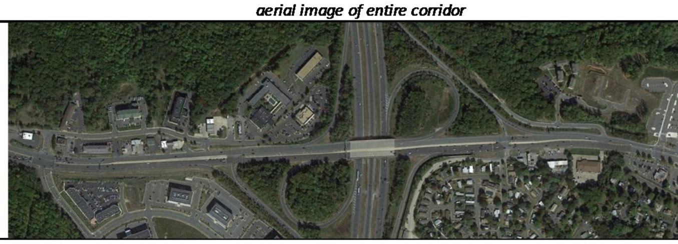
Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	2
Percent of Parcels w/ Sidewalks:	*50%*

Site: VA #1: Partial Cloverleaf

West

aerial image of entire corridor



East

street-view of corridor cross-section

Interchange Type:	Partial-Cloverleaf	**East Terminal Right Turn Type:**	Free
Terminal Control Type:	Signal	**West Terminal Right Turn Type:**	Free

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.39
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	50
Roadway Operating Speed (mph):	31.4
Roadway Volume (AADT):	45,000
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	820.0
Side of Road:	Right
Driveway Type:	Right-In/Right-Out
Nearest Intersection (ft):	2034.2
ntersection Control Type:	Signal

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	n/a
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	0
Signals per Mile:	*5.2*
Intersections per Mile:	*5.2*
Full Movement Driveways:	0
3/4 Movement Driveways:	0
RIRO Driveways:	9
Driveways per Mile:	*23*
Minimum Driveway Spacing (ft):	26.8
Maximum Driveway Spacing (ft):	273.1

Land Use Data

Land Use Type:

Commercial (Percentage):	70%
Industrial (Percentage):	30%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	13
Average DWs per Parcel:	*0.69*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	2
Total Crashes:	*2.00*
Average Crashes per Year:	*0.67*
Average Crashes per Mile per Year:	*5.19*
Average Crash Rate:	*10.54*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*50%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*50%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	50%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	1
Percent of Parcels w/ Sidewalks:	*8%*

Site: VA #1: Partial Cloverleaf

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.34
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	23.6
Roadway Volume (AADT):	36,000
Number of Through Lanes:	6
Median Type (1):	Raised
(Percentage):	90%
Median Type (2):	Painted
(Percentage):	10%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	524.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	1805.0
ntersection Control Type:	Signal

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	548.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	2
Unsignalized Intersections:	1
Signals per Mile:	*5.9*
Intersections per Mile:	*8.8*
Full Movement Driveways:	3
3/4 Movement Driveways:	0
RIRO Driveways:	5
Driveways per Mile:	*23.4*
Minimum Driveway Spacing (ft):	44.2
Maximum Driveway Spacing (ft):	415.2

Land Use Data

Land Use Type:

Commercial (Percentage):	40%
Industrial (Percentage):	20%
Residential (Percentage):	30%
Vacant (Percentage):	10%
Total (Percentage):	*100%*
Number of Developed Parcels:	8
Average DWs per Parcel:	*1.00*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*20.48*
Average Crash Rate:	*10.54*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	20%
Number of Marked Crosswalks:	1
Crosswalks per Mile:	*2.93*
Crosswalks per Intersection:	*0.33*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: VA #2: Stop Controlled Diamond

aerial image of entire corridor

West

street-view of corridor cross-section

East

Interchange Type:	Diamond	**East Terminal Right Turn Type:**	Stop
Terminal Control Type:	2-Way Stop	**West Terminal Right Turn Type:**	Stop

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.09
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	41.8
Roadway Volume (AADT):	9,900
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	385.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	199.6
ntersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	210.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	0
Unsignalized Intersections:	1
Signals per Mile:	*0*
Intersections per Mile:	*11.1*
Full Movement Driveways:	2
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*22*
Minimum Driveway Spacing (ft):	131.1
Maximum Driveway Spacing (ft):	384.8

Land Use Data

Land Use Type:

Commercial (Percentage):	100%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	0%
Total (Percentage):	*100%*
Number of Developed Parcels:	3
Average DWs per Parcel:	*0.67*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	2
Number of PDO Crashes (O):	5
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*77.97*
Average Crash Rate:	*719.29*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*14%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*14%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: VA #2: Stop Controlled Diamond

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.25
Endpoint Type:	Unsignalized Intersection
Roadway Posted Speed (mph):	45
Roadway Operating Speed (mph):	43.3
Roadway Volume (AADT):	4,600
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:

Nearest DS Driveway (ft):	437.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	1305.0
ntersection Control Type:	Other

Distance from NB On-Ramp to:

Nearest US Driveway (ft):	388.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	0
Unsignalized Intersections:	2
Signals per Mile:	*0*
Intersections per Mile:	*8.1*
Full Movement Driveways:	6
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*24.3*
Minimum Driveway Spacing (ft):	14.0
Maximum Driveway Spacing (ft):	398.0

Land Use Data

Land Use Type:

Commercial (Percentage):	40%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	60%
Total (Percentage):	*100%*
Number of Developed Parcels:	3
Average DWs per Parcel:	*2.00*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	3
Number of PDO Crashes (O):	7
Total Crashes:	*11.00*
Average Crashes per Year:	*3.67*
Average Crashes per Mile per Year:	*44.51*
Average Crash Rate:	*719.29*
Number of Driveway-Related Crashes:	3
Percent Driveway Crashes:	*27%*
umber of Intersection-Related Crashes:	4
Percent Intersection Crashes:	*36%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.51
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	28
Roadway Volume (AADT):	12,000
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	182.5
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	182.5
ntersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	127.3
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	4
Signals per Mile:	*2*
Intersections per Mile:	*9.8*
Full Movement Driveways:	19
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*37*
Minimum Driveway Spacing (ft):	24.1
Maximum Driveway Spacing (ft):	109.5

Land Use Data

Land Use Type:

Commercial (Percentage):	30%
Industrial (Percentage):	0%
Residential (Percentage):	10%
Vacant (Percentage):	60%
Total (Percentage):	*100%*
Number of Developed Parcels:	12
Average DWs per Parcel:	*1.58*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	1
Number of PDO Crashes (O):	2
Total Crashes:	*3.00*
Average Crashes per Year:	*1.00*
Average Crashes per Mile per Year:	*5.87*
Average Crash Rate:	*44.66*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*33%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*33%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: VA #3: Stop Controlled Diamond

aerial image of entire corridor

West

street-view of corridor cross-section

West

Interchange Type:	Diamond	**East Terminal Right Turn Type:**	Stop
Terminal Control Type:	2-Way Stop	**West Terminal Right Turn Type:**	Stop

West Side of Interchange

Roadway Data

Corridor Length (mi):	0.51
Endpoint Type:	Signalized Intersection
Roadway Posted Speed (mph):	35
Roadway Operating Speed (mph):	28
Roadway Volume (AADT):	12,000
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from SB Off-Ramp to:

Nearest DS Driveway (ft):	182.5
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	182.5
ntersection Control Type:	2-Way Stop

Distance from SB On-Ramp to:

Nearest US Driveway (ft):	127.3
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:

Signalized Intersections:	1
Unsignalized Intersections:	4
Signals per Mile:	*2*
Intersections per Mile:	*9.8*
Full Movement Driveways:	19
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*37*
Minimum Driveway Spacing (ft):	24.1
Maximum Driveway Spacing (ft):	109.5

Land Use Data

Land Use Type:

Commercial (Percentage):	30%
Industrial (Percentage):	0%
Residential (Percentage):	10%
Vacant (Percentage):	60%
Total (Percentage):	*100%*
Number of Developed Parcels:	12
Average DWs per Parcel:	*1.58*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	0
Number of Injury Crashes (A, B):	1
Number of PDO Crashes (O):	2
Total Crashes:	*3.00*
Average Crashes per Year:	*1.00*
Average Crashes per Mile per Year:	*5.87*
Average Crash Rate:	*44.66*
Number of Driveway-Related Crashes:	1
Percent Driveway Crashes:	*33%*
umber of Intersection-Related Crashes:	1
Percent Intersection Crashes:	*33%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadwa

Sidewalks (Percentage):	0%
Number of Marked Crosswalks:	0
Crosswalks per Mile:	*0.00*
Crosswalks per Intersection:	*0.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*

Number of Developments Providing:

Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	0
Percent of Parcels w/ Sidewalks:	*0%*

Site: VA #3: Stop Controlled Diamond

East Side of Interchange

Roadway Data

Corridor Length (mi):	0.26
Endpoint Type:	Driveway
Roadway Posted Speed (mph):	55
Roadway Operating Speed (mph):	38.8
Roadway Volume (AADT):	1,900
Number of Through Lanes:	2
Median Type (1):	Undivided
(Percentage):	100%
Median Type (2):	N/A
(Percentage):	0%
Median Type (3):	N/A
(Percentage):	0%

Interchange Data

Distance from NB Off-Ramp to:	
Nearest DS Driveway (ft):	145.0
Side of Road:	Right
Driveway Type:	Full Movement
Nearest Intersection (ft):	140.5
ntersection Control Type:	2-Way Stop
Distance from NB On-Ramp to:	
Nearest US Driveway (ft):	127.0
Side of Road:	Right
Driveway Type:	Full Movement

Driveway Data

Number of:	
Signalized Intersections:	0
Unsignalized Intersections:	2
Signals per Mile:	*0*
Intersections per Mile:	*7.6*
Full Movement Driveways:	6
3/4 Movement Driveways:	0
RIRO Driveways:	0
Driveways per Mile:	*22.8*
Minimum Driveway Spacing (ft):	93.9
Maximum Driveway Spacing (ft):	124.7

Land Use Data

Land Use Type:	
Commercial (Percentage):	40%
Industrial (Percentage):	0%
Residential (Percentage):	0%
Vacant (Percentage):	60%
Total (Percentage):	*100%*
Number of Developed Parcels:	3
Average DWs per Parcel:	*2.00*

Safety Data

Years of Data:	3
Number of Fatal Crashes (K):	1
Number of Injury Crashes (A, B):	0
Number of PDO Crashes (O):	6
Total Crashes:	*7.00*
Average Crashes per Year:	*2.33*
Average Crashes per Mile per Year:	*26.55*
Average Crash Rate:	*44.66*
Number of Driveway-Related Crashes:	4
Percent Driveway Crashes:	*57%*
umber of Intersection-Related Crashes:	2
Percent Intersection Crashes:	*29%*
Number of Bicycle-Related Crashes	0
Percent Bicycle Crashes:	*0%*
Number of Pedestrian-Related Crashes:	0
Percent Pedestrian Crashes:	*0%*

Accessibility Data

Bike, Ped, Transit on Major Roadway:	
Sidewalks (Percentage):	70%
Number of Marked Crosswalks:	2
Crosswalks per Mile:	*7.59*
Crosswalks per Intersection:	*1.00*
Bicycle Lanes (Percentage):	0%
Number of Transit Stops:	0
Transit Stops per Mile:	*0.00*
Number of Developments Providing:	
Bicycle Storage:	0
Percent of Parcels w/ Bike Storage:	*0%*
Continuous Sidewalks (road to door):	1
Percent of Parcels w/ Sidewalks:	*33%*

APPENDIX D: VISSIM MODEL VALIDATION

VISSIM Model Validation Results

The following spreadsheets summarize the VISSIM model validation process and results for each of the ten study locations. The fields are defined as follows:

- VISSIM Travel Time Measurement – Reference number of travel time measurement location (four sections at each site, as described in Chapter V)
- VISSIM Measurement Distance – Distance in feet between the two endpoints of the travel time measurement section within the simulated network
- Field Measurement Distance – Average distance in feet between the two endpoints of the travel time measurement section as measured in the field
- Number of VISSIM Measurements – Number of vehicles that traveled through the entire travel time section during the recorded simulation run
- Number of Field Measurements – Number of travel time runs conducted in the field for that travel time section and traffic volume scenario
- VISSIM Average TT – Average travel time in seconds for that travel time section, as reported in VISSIM
- 1 STD DEV (2 STD DEV) – One (two) standard deviation of the simulated travel time data.
- Field Study Average TT – Average travel time in seconds of all relevant field travel time runs for that travel time segment
- Adjusted Field Study Average TT – The average travel time in seconds of all relevant field travel time runs, adjusted to account for the slight difference the field and simulated travel time section distance
- TT Difference – The difference in seconds between the VISSIM Average TT and Adjusted Field Study Average TT. This cell is green when the difference is less than 2 STD DEV of the simulated data
- VISSIM Average Speed – The average simulated speed in mph along the travel time segment, calculated from the travel time and travel distance
- Field Study Speed – The average speed in mph along the travel time segment during field study runs, calculated from the travel time and travel distance
- Difference – The difference between the field and simulated speed along the travel time segment, reported in both mph and percent difference

State	Arkansas
Location	AR 1

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	687.1	666.27	1012	1086	6	2
2	690.5	678.20	1022	1317	2	1
3	1369	1375.03	1219	1246	4	0
4	1367.4	1373.57	1128	1230	4	2

Off-Peak Period

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	15.13	0.36	0.71	13	13.4	1.72
2	18.94	1.99	3.98	16	16.3	2.65
3	30.01	1.11	2.21	32	31.9	1.85
4	51.65	4.56	9.11	49	48.8	2.87

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	30.97	34.94	3.97	12.0%
2	24.85	28.90	4.05	15.1%
3	31.11	29.30	1.81	6.0%
4	18.05	19.11	1.06	5.7%

Peak Period

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	15.75	0.53	1.06	18	18.6	2.82
2	22.94	2.30	4.61	21	21.4	1.56
3	28.83	0.29	0.58	n/a	n/a	n/a
4	43.50	5.72	11.44	37	36.8	6.67

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	29.75	25.24	4.52	16.4%
2	20.52	22.02	1.50	7.0%
3	32.37	n/a	n/a	n/a
4	21.43	25.31	3.88	16.6%

State	Arkansas
Location	AR 2

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	445.31	468.52	n/a	135	n/a	4
2	511.97	509.58	n/a	420	n/a	4
3	508.88	485.37	n/a	1048	n/a	4
4	440.85	416.01	n/a	631	n/a	4

Peak Period, 7:15-8:15am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	6.13	0.24	0.47	6.00	5.7	0.42
2	11.90	0.68	1.35	12.00	12.1	0.16
3	11.19	1.53	3.05	10.00	10.5	0.71
4	7.67	1.10	2.19	7.00	7.4	0.25

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	49.55	53.24	3.69	7.2%
2	29.35	28.95	0.39	1.3%
3	31.00	33.09	2.09	6.5%
4	39.19	40.52	1.33	3.3%

State	Arkansas
Location	AR 3

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	846.66	902.80	589	1062	2	4
2	842.43	849.19	645	945	3	5
3	652.48	641.41	601	1089	4	4
4	655.92	666.09	739	1164	5	5

Off-Peak Period, 9:30-10:30am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	27.73	1.51	3.02	32	30.0	2.29
2	17.96	0.27	0.54	19	18.8	0.89
3	33.91	1.69	3.38	34	34.6	0.68
4	17.93	0.62	1.25	17	16.7	1.19

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	20.82	19.24	1.59	7.9%
2	31.99	30.47	1.51	4.8%
3	13.12	12.86	0.26	2.0%
4	24.94	26.72	1.77	6.9%

Peak Period, 3:30-4:30pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	29.33	1.67	3.34	30.00	28.1	1.19
2	18.04	0.47	0.94	19.00	18.8	0.81
3	19.25	1.09	2.18	19.00	19.3	0.08
4	16.30	3.61	7.22	20.00	19.7	3.40

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	19.68	20.52	0.83	4.2%
2	31.84	30.47	1.37	4.4%
3	23.11	23.02	0.10	0.4%
4	27.44	22.71	4.73	18.9%

State	Arkansas
Location	AR 4

VISSIM Trave Time Measurement	**VISSIM Measurement Distance (ft)**	**Field Measurement Distance (ft)**	**Number of VISSIM Measurements**		**Number of Field Measurements**	
			Off Peak	**Peak**	**Off Peak**	**Peak**
1	481.15	477.17	n/a	797	n/a	3
2	1857.90	1769.83	n/a	739	n/a	2
3	1838.31	1947.15	n/a	696	n/a	2
4	486.77	489.32	n/a	912	n/a	2

Peak Period, 1:00-2:00pm

VISSIM Travel Time Measurement	**VISSIM Average TT (sec)**	**1 STD DEV (sec)**	**2 STD DEV (sec)**	**Field Study Average TT (sec)**	**Adjusted Field Study Average TT (sec)**	**TT Difference (sec)**
1	55.48	1.26	2.52	60.00	60.5	5.02
2	58.63	1.27	2.54	57.00	59.8	1.21
3	76.49	1.86	3.73	83.00	78.4	1.87
4	30.58	1.28	2.56	33.00	32.8	2.25

VISSIM Travel Time Measurement	**VISSIM Average Speed (mph)**	**Field Study Speed (mph)**	**Difference (mph)**	**Difference (%)**
1	5.91	5.42	0.49	8.7%
2	21.61	21.17	0.44	2.0%
3	16.39	16.00	0.39	2.4%
4	10.85	10.11	0.74	7.1%

State	Arizona
Location	AZ1

VISSIM Travel Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	1055.19	1055.43	n/a	444	n/a	9
2	1055.38	1055.43	n/a	715	n/a	9
3	1257.76	1248.18	n/a	464	n/a	9
4	1252.78	1248.18	n/a	415	n/a	9

Peak Period, 2:00-3:00pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	68.69	3.16	6.32	67.10	67.1	1.61
2	22.15	0.23	0.45	22.00	22.0	0.15
3	22.78	0.20	0.40	21.70	21.9	0.92
4	50.84	1.88	3.77	49.50	49.7	1.16

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	10.47	10.72	0.25	2.4%
2	32.48	32.71	0.23	0.7%
3	37.64	39.22	1.58	4.1%
4	16.80	17.19	0.39	2.3%

State	Arizona
Location	AZ 2

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	1137.35	1150.42	235	477	10	8
2	1138.17	1150.42	292	471	9	7
3	767.79	746.72	166	394	10	7
4	767.04	746.72	254	455	9	7

Off-Peak Period, 9:15-10:15am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	22.23	0.23	0.46	21.30	21.1	1.17
2	42.09	3.10	6.21	38.56	38.1	3.95
3	37.67	4.57	9.13	35.70	36.7	0.97
4	16.87	0.50	1.00	17.00	17.5	0.59

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	34.89	36.83	1.94	5.4%
2	18.44	20.34	1.91	9.8%
3	13.90	14.26	0.37	2.6%
4	31.00	29.95	1.05	3.5%

Peak Period, 4:30-5:30pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	21.11	0.18	0.36	20.13	19.9	1.21
2	68.46	5.30	10.59	74.86	74.1	5.60
3	70.54	20.74	41.47	69.43	71.4	0.85
4	34.81	2.58	5.15	30.14	31.0	3.85

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	36.74	38.98	2.24	5.9%
2	11.34	10.48	0.86	7.9%
3	7.42	7.33	0.09	1.2%
4	15.02	16.89	1.87	11.7%

State	Arizona
Location	AZ 3

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	1176.92	1174.16	n/a	135	n/a	7
2	1179.85	1174.16	n/a	420	n/a	8
3	941.41	950.94	n/a	1048	n/a	7
4	944.31	950.94	n/a	631	n/a	8

Peak Period, 7:00-8:00am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	84.50	5.62	11.25	86.57	86.8	2.27
2	34.41	2.82	5.64	36.38	36.6	2.14
3	36.11	5.25	10.49	32.57	32.2	3.86
4	50.20	4.56	9.11	49.50	49.2	1.04

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	9.50	9.25	0.25	2.7%
2	23.38	22.01	1.37	6.0%
3	17.78	19.91	2.13	11.3%
4	12.83	13.10	0.27	2.1%

State	Arizona
Location	AZ 5

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	1065.31	1041.45	725	994	10	9
2	1071.77	1041.45	872	1564	10	9
3	1651.93	1601.52	843	933	10	9
4	1649.09	1601.52	764	1645	10	10

Off-Peak Period, 9:00-10:00am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	43.28	3.06	6.12	41.40	42.3	0.94
2	21.59	0.70	1.41	19.90	20.5	1.11
3	26.72	0.28	0.56	27.90	28.8	2.06
4	71.09	3.09	6.19	70.60	72.7	1.60

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	16.78	17.15	0.37	2.2%
2	33.84	35.68	1.84	5.3%
3	42.16	39.14	3.02	7.4%
4	15.82	15.47	0.35	2.2%

Peak Period, 5:30-6:30pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	62.83	1.25	2.51	59.10	60.5	2.37
2	30.22	1.26	2.51	27.10	27.9	2.33
3	26.84	0.15	0.30	26.70	27.5	0.70
4	65.87	2.91	5.82	66.50	68.5	2.61

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	11.56	12.01	0.45	3.9%
2	24.18	26.20	2.02	8.0%
3	41.97	40.90	1.07	2.6%
4	17.07	16.42	0.65	3.9%

State	Texas
Location	TX 2

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	453.35	453.84	270	819	11	5
2	453.88	455.06	260	490	9	5
3	928.73	917.23	169	715	9	5
4	927.97	906.52	192	354	9	5

Off-Peak Period, 10:20-11:20am

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	17.42	0.78	1.55	18.00	18.0	0.57
2	18.91	2.19	4.38	16.00	16.0	2.95
3	26.43	2.77	5.53	30.00	30.4	3.95
4	35.46	3.30	6.59	40.00	40.9	5.49

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	17.75	17.19	0.56	3.2%
2	16.36	19.39	3.03	16.9%
3	23.96	20.85	3.11	13.9%
4	17.84	15.45	2.39	14.4%

Peak Period, 5:00-6:00pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	13.72	0.72	1.43	13.00	13.0	0.73
2	14.84	2.62	5.24	13.00	13.0	1.88
3	51.54	2.24	4.48	49.00	49.6	1.92
4	26.24	3.32	6.64	27.00	27.6	1.40

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	22.54	23.80	1.27	5.5%
2	20.85	23.87	3.02	13.5%
3	12.29	12.76	0.48	3.8%
4	24.12	22.89	1.23	5.2%

State	Virginia
Location	VA 1

VISSIM Trave Time Measurement	VISSIM Measurement Distance (ft)	Field Measurement Distance (ft)	Number of VISSIM Measurements		Number of Field Measurements	
			Off Peak	Peak	Off Peak	Peak
1	1481.35	1490.15	749	892	6	5
2	1243.64	1236.38	647	845	7	5
3	1234.37	1296.81	999	1328	6	5
4	1473.80	1461.93	755	1549	7	5

Off-Peak Period, 11:00am-12:00pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV	2 STD DEV	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	23.85	0.45	0.90	25.00	24.9	1.00
2	37.97	2.07	4.14	37.00	37.2	0.76
3	20.31	0.41	0.82	21.00	20.0	0.32
4	31.87	0.86	1.72	31.00	31.3	0.62

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	42.35	40.64	1.71	4.1%
2	22.33	22.78	0.45	2.0%
3	41.45	42.10	0.66	1.6%
4	31.53	32.15	0.62	2.0%

Peak Period, 4:00-5:00pm

VISSIM Travel Time Measurement	VISSIM Average TT (sec)	1 STD DEV (sec)	2 STD DEV (sec)	Field Study Average TT (sec)	Adjusted Field Study Average TT (sec)	TT Difference (sec)
1	26.72	0.66	1.33	26.00	25.8	0.87
2	44.51	1.94	3.87	45.00	45.3	0.76
3	31.64	1.68	3.35	31.00	29.5	2.13
4	45.71	1.70	3.40	42.00	42.3	3.37

VISSIM Travel Time Measurement	VISSIM Average Speed (mph)	Field Study Speed (mph)	Difference (mph)	Difference (%)
1	37.80	39.08	1.27	3.3%
2	19.05	18.73	0.32	1.7%
3	26.60	28.52	1.92	7.0%
4	21.98	23.73	1.75	7.7%